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Debris/Ice /TPS Assessment and Integrated Photographic Analysis for Shuttle Mission STS-56

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ORIGINAL CONTAINS
COLOR ILLUSTRATIONS

DEBRIS/ICE/TPS ASSESSMENT
AND
PHOTOGRAPHIC ANALYSIS
OF
SHUTTLE MISSION STS-56

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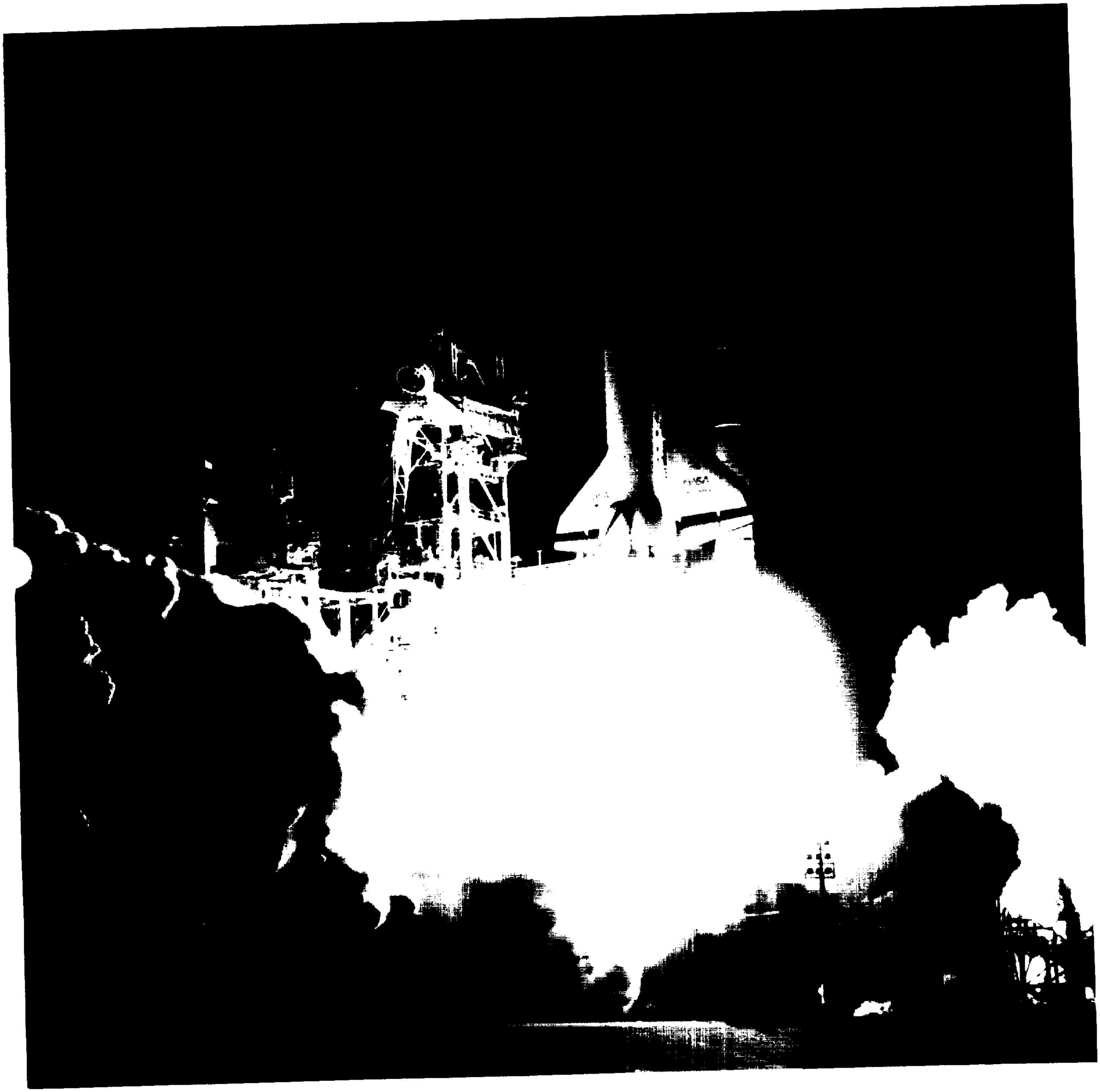
FOREWORD

The Debris Team has developed and implemented measures to control damage from debris in the Shuttle operational environment and to make the control measures a part of routine launch flows. These measures include engineering surveillance during vehicle processing and closeout operations, facility and flight hardware inspections before and after launch, and photographic analysis of mission events.

Photographic analyses of mission imagery from launch, on-orbit, and landing provide significant data in verifying proper operation of systems and evaluating anomalies. In addition to the Kennedy Space Center (KSC) Photo/Video Analysis, reports from Johnson Space Center, Marshall Space Flight Center, and Rockwell International - Downey are also included in this document to provide an integrated assessment of the mission.



Shuttle Mission STS-56 was launched at 1:29 a.m. local 4/8/93

1.0 Summary

The pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 4 April 1993. The detailed walkdown of Launch Pad 39B and MLP-1 also included the primary flight elements OV-103 Discovery (16th flight), ET-54 (LWT 47), and BI-058 SRB's. There were no vehicle anomalies.

An Ice/Frost Inspection of the cryoloaded vehicle was performed on 5 April 1993. There were no Launch Commit Criteria, OMRS, or NSTS-08303 violations. There were no conditions outside of the established data base. In spite of the warm ambient weather conditions, an ice/frost line formed along the edge of the LH2 tank PAL ramp and three of the cable tray ice/frost ramp aft edges. A 12 inch long by 1/4-inch wide crack was visible in the -Y vertical strut cable tray forward surface TPS near the longeron closeout interface. The crack, which exhibited no offset and was not filled with ice or frost, was acceptable for launch per the NSTS-08303 criteria. IPR 56V-0105 taken against dark markings on the LH SRB case near the center field joint closeout appeared to be deposits of field joint closeout grease.

The launch of STS-56 was aborted due to a problem with the MPS LH2 high point bleed valve instrumentation. No significant vehicle damage was observed during the external post drain inspection. No IPR's were taken as a result of the inspection and all TPS anomalies were acceptable for the next launch attempt per the NSTS-08303 criteria.

An Ice/Frost Inspection of the cryoloaded vehicle was performed for the second launch attempt on 7 April 1993 during the two hour built-in-hold at T-3 hours in the countdown. There were no Launch Commit Criteria, OMRS, or NSTS-08303 violations. One IPR was taken due to a GH2 vent line hydrogen leak. The External Tank exhibited light condensate on the TPS acreage. The LH2 ET/ORB umbilical leak sensor detected no significant hydrogen leakage during the cryoload. No unusual vapors or cryogenic drips were visible during tanking, stable replenish, and launch.

A 12-inch long crack in the -Y vertical strut cable tray forward surface TPS near the longeron closeout interface (previously observed during the first cryoload) had increased in length. A 4-inch crack, propagating outboard from the ET interface, is most likely a continuation of the 12-inch crack along the inboard side of the vertical strut/cable tray. The 4-inch crack exhibited some offset, which was caused by structural deflection rather than a TPS debond. The appearance of the crack was expected due to the elimination of the stress relief gap at the factory and was acceptable for flight per the NSTS-08303 criteria.

Venting vapors and an ice/frost buildup at the GH2 vent line 90 degree elbow/flex line flange (covered by an ice shroud) indicated the presence of a hydrogen leak, which was confirmed by a hydrogen detection meter. Since the leaking hydrogen was not driven by a pressurized GH2 vent line, and the line itself would be purged at T-90 seconds, the condition was not a constraint to launch. The ice buildup measured 10" x 4" x 3/8" thick and may have been a debris threat to Orbiter tiles. However, the easterly winds and the structurally enclosed area of the ice buildup would prevent large pieces of ice from falling toward the vehicle. Post launch disassembly of the elbow/flex line flange revealed the old Fluorogreen gasket, which was cracked, had not been removed prior to installation of the new Fluorogold gasket. In addition, the flange bolts had not been re-torqued after the last cryogenic loading cycle.

A debris inspection of Pad 39B was performed after launch. A plunger, spring, and associated hardware from the Debris Containment System (DCS) was found on holddown post #5 still attached to the stud. This hardware is normally contained in the DCS housing and remains with the SRB aft skirt during flight. No TPS materials or other flight hardware were found. No frangible nut/ordnance fragments were found. Damage to the facility overall was minimal.

A total of 129 film and video items were analyzed as part of the post launch data review. No major vehicle damage or lost flight hardware was observed that would have affected the mission. No film data of the HDP #5 DCS plunger anomaly was obtained due to film breakage in the closest camera. No other MLP or FSS films viewed the HDP #5 area. However, several films viewing the Orbiter lower surface showed no unidentified debris objects moving toward the Orbiter from the LH SRB aft skirt area and no obvious tile damage from debris impacts. No stud hang-ups occurred and no ordnance debris fell from any of the HDP DCS/stud holes. All T-0 umbilicals operated properly.

On-orbit imagery from the flight crew handheld photography revealed as many as 12 divots in the LH2 tank-to-intertank flange closeout on the ET -Z side. Some of the divots were 10-12 inches in diameter. As many as 11 divots were also present in the intertank acreage on the -Z side of the ET. Numerous divots appeared in a line and may be indicative of a spray or processing problem. Depth could not be determined due to the absence of shadows or stringers being visible in the divots. Several of the divots were estimated to be 24 inches in diameter. An IFA was taken against the new block of intertanks, which have shown an increasing trend in the appearance of acreage divots.

Film analysis showed Orbiter flight performance, landing gear extension, wheel touchdown, drag chute deployment, and rollout were normal.

The Solid Rocket Boosters were inspected at Hanger AF after retrieval. Both frustums were missing no TPS, but had a total of 31 MSA-2 debonds over fasteners. Examination of the HDP #5 stud hole revealed no obvious broaching or unusual abrasion due to the loss of the Debris Containment System (DCS) plunger and spring. The frangible nut halves were contained inside the DCS housing. The other DCS plungers were seated properly. None of the aft skirt HDP EPON shim material was lost at lift off.

The HDP #5 DCS failure scenario suggests the frangible nut halves rebounded off the lead liner, symmetrically contacted the plunger assembly, and caused localized deformation to the plunger, which in turn allowed the plunger to pass through the stud hole. Once clear of the aft skirt/DCS housing, the plunger and spring became debris that could have been deflected by SRB plume impingement resulting in a potential threat to the vehicle. In this case, the frangible link connecting the plunger to the stud survived the launch environment.

Although a Rockwell-MSFC study calculated low probabilities for DCS debris to impact flight hardware, the Shuttle program acknowledged the potential threat by authorizing/funding the Debris Containment System. However, the study was based upon the size of expected ordnance debris objects (NSI cartridges and frangible nut webs). The presence of a larger, more massive, debris object (plunger and spring) in the launch environment is not acceptable. The DCS plunger should be modified or redesigned to avoid another occurrence.

Diagonal-cutting pliers fell out of the HDP #4 DCS area and were most likely wedged between the DCS housing and the RH aft skirt forged foot web for flight. The lost tool had been reported prior to launch, but no search was performed. The tool control plan will be changed to add specific instructions to be followed when a tool is reported missing or lost, final area inspections will be modified, and a retraining program for pad workers will be conducted.

A detailed post landing inspection of OV-103 was performed after the KSC landing. The Orbiter TPS sustained a total of 156 hits, of which 36 had a major dimension of one inch or greater. The Orbiter lower surface had a total of 94 hits, of which 18 had a major dimension of one inch or greater. Based on these numbers and comparison to statistics from previous missions of similar configuration, the total number of Orbiter TPS debris hits was near average and the number of hits one inch or larger was greater than average. The largest tile damage site measured 9.0" x 2.0" x 0.2" (involving two tiles) and was located on the lower surface of the RH wing leading edge extension (glove area). The shallow depth of 0.2 inches is indicative of an impact by low density material, such as ET SOFI.

The tiles on the LH OMS pod leading edge sustained more damage than usual (at least 35 hits, of which 15 had a major dimension of 1 inch or greater). Several of the tile damage sites reached a depth ranging from 0.5 to approximately 1.3 inches. The cause of this damage is believed to be ice from the waste water dump nozzle near the crew hatch. All three ET/Orbiter separation devices (EO-1, 2, and 3) and all ET/ORB umbilical separation ordnance retention shutters functioned properly. No flight hardware was found on the runway below the umbilicals when the ET doors were opened.

Orbiter post landing microchemical sample results revealed a variety of residuals from sources such as Orbiter TPS, SRB BSM exhaust residue, landing site products, organics, and paint. New findings to this sampling effort were all obtained from the window samples, though the exact source of these residual items is still under investigation. The residual sample data do not indicate a single source of damaging debris since none of the observed materials was associated with a damage site. The residual sample data also showed no debris trends when compared to previous mission data.

A total of 8 Post Launch Anomalies, including 2 IFA candidates, were observed during the STS-56 mission assessment.

2.0 PRE-LAUNCH BRIEFING

The Ice/Debris/TPS/Photographic Analysis Team briefing for launch activities was conducted on 2 April 1993 at 1430 hours with the following key personnel present:

B. Davis	NASA - KSC	STI, Ice/Debris Assessment
G. Katnik	NASA - KSC	Shuttle Ice/Debris Systems
B. Speece	NASA - KSC	Lead, ET Thermal Protection
B. Bowen	NASA - KSC	ET Processing, Ice/Debris
K. Tenbusch	NASA - KSC	ET Processing, Ice/Debris
P. Rosado	NASA - KSC	Chief, ET Mechanical Systems
J. Rivera	NASA - KSC	Lead, ET Structures
M. Bassignani	NASA - KSC	ET Structures/Handling
J. Cawby	LSOC - SPC	Supervisor, ET Processing
M. Jaime	LSOC - SPC	ET Processing
G. Fales	LSOC - SPC	ET Processing
W. Richards	LSOC - SPC	ET Processing
J. McClymonds	RI - DNY	Debris Assess, LVL II Integ
W. Atkinson	RI - LSS	Vehicle Integration
R. Hillard	MTI - LSS	SRM Processing
B. Ferrell	MMC - LSS	ET Processing
J. Phillips	LSOC - SPC	Safety
C. Martin	NASA - KSC	Level II Representative

These personnel participated in various team activities, assisted in the collection and evaluation of data, and contributed to reports contained in this document.

2.1 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

A pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 4 April 1993 from 1700-1815 hours. The detailed walkdown of Launch Pad 39B and MLP-1 also included the primary flight elements OV-103 Discovery (16th flight), ET-54 (LWT 47), and BI-058 SRB's. Documentary photographs were taken of facility anomalies, potential sources of vehicle damaging debris, and vehicle configuration changes.

There were no significant vehicle anomalies or debris issues.

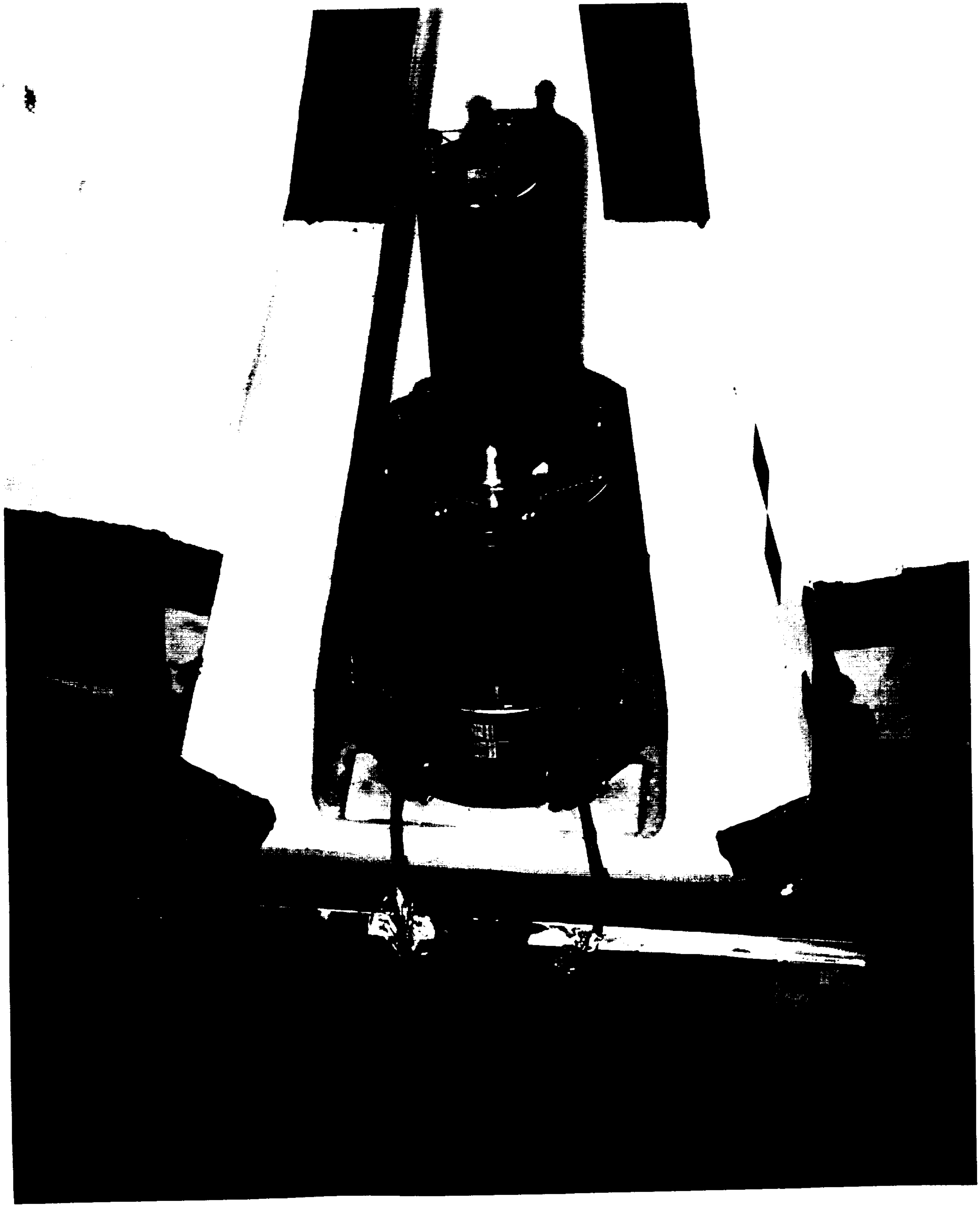
Due to the continued concern over potential hydrogen leakage from the ET/ORB LH2 umbilical interface area during cryoload and launch, tygon tubes for hydrogen leak detectors LD54 and LD55 were installed at the LH2 ET/ORB umbilical. The tygon tubes are intended to remain in place during cryogenic loading and be removed by the Ice Team during the T-3 hour hold.

From a facility standpoint, access panel bolts on the MLP deck east of the RH SRB and under the raised deck between the RH and LH SRB's were loose. A system of marking deck bolts that have already been tightened/torqued was proposed to Pad Operations.

The MLP deck, rain gutters, and areas under the raised decks were swept/vacuumed again prior to launch to remove small debris items, such as sand, rust flakes, and paint chips.

The loose deck bolts and sweeping of the MLP deck were the only two items entered in S0007, Appendix K.

A conduit cap was found under the MLP raised deck during the pre-launch debris inspection



Pre-launch configuration of the Holddown Post (HDP) #5
Debris Containment System (DCS)- exterior view

3.0 ABORT

The launch of STS-56 was aborted at T-11 seconds due to an instrumentation problem with the MPS LH2 high point bleed valve.

3.1 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 5 April 1993 from 2100 to 2250 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no Launch Commit Criteria, OMRS, or NSTS-08303 violations. There were no conditions outside of the established data base. Ambient weather conditions at the time of the inspection were:

Temperature:	66.4 Degrees F
Relative Humidity:	57.9 Percent
Wind Speed:	12.1 Knots
Wind Direction:	254 Degrees

A portable Shuttle Thermal Imager (STI) infrared scanning radiometer was utilized to obtain vehicle surface temperature measurements for an overall thermal assessment of the vehicle, as shown in Figures 1 and 2.

3.2 ORBITER

No Orbiter TPS or RCC panel anomalies were observed. All RCS thruster paper covers and water spray boiler plugs were intact. Typical ice and frost accumulations were present at the SSME #1 and #2 heat shield-to-nozzle interfaces. The SSME #3 heat shield was wet with condensate. The base heat shield tiles were dry. An infrared scan revealed no unusual temperature gradients on the base heat shield or engine mounted heat shields. No unusual vapors originated from inside the SSME nozzles.

3.3 SOLID ROCKET BOOSTERS

No SRB anomalies or loose ablator/cork were observed. IPR 56V-0105 taken against dark markings on the LH SRB case near the center field joint closeout appeared to be deposits of field joint closeout grease. The STI portable infrared scanner recorded RH and LH SRB case temperatures between 70 and 72 degrees Fahrenheit (F). In comparison, temperatures measured by a hand-held Minolta/Land Cyclops spot radiometer ranged from 69 to 72 degrees F and the SRB Ground Environment Instrumentation (GEI) measured temperatures of 70-73 degrees F. All measured temperatures were above the 34 degrees F minimum requirement. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 70 degrees F, which was within the required range of 44-86 degrees F.

FIGURE 1. **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**

TIME: approx. 2100EDT
DATE: 4/5/93
VEH. STS- 56 (Abort)

ALL MEASUREMENTS IN DEGREES FAHRENHEIT

TARGET EMISSIVITY ASSUMED TO BE 1.0

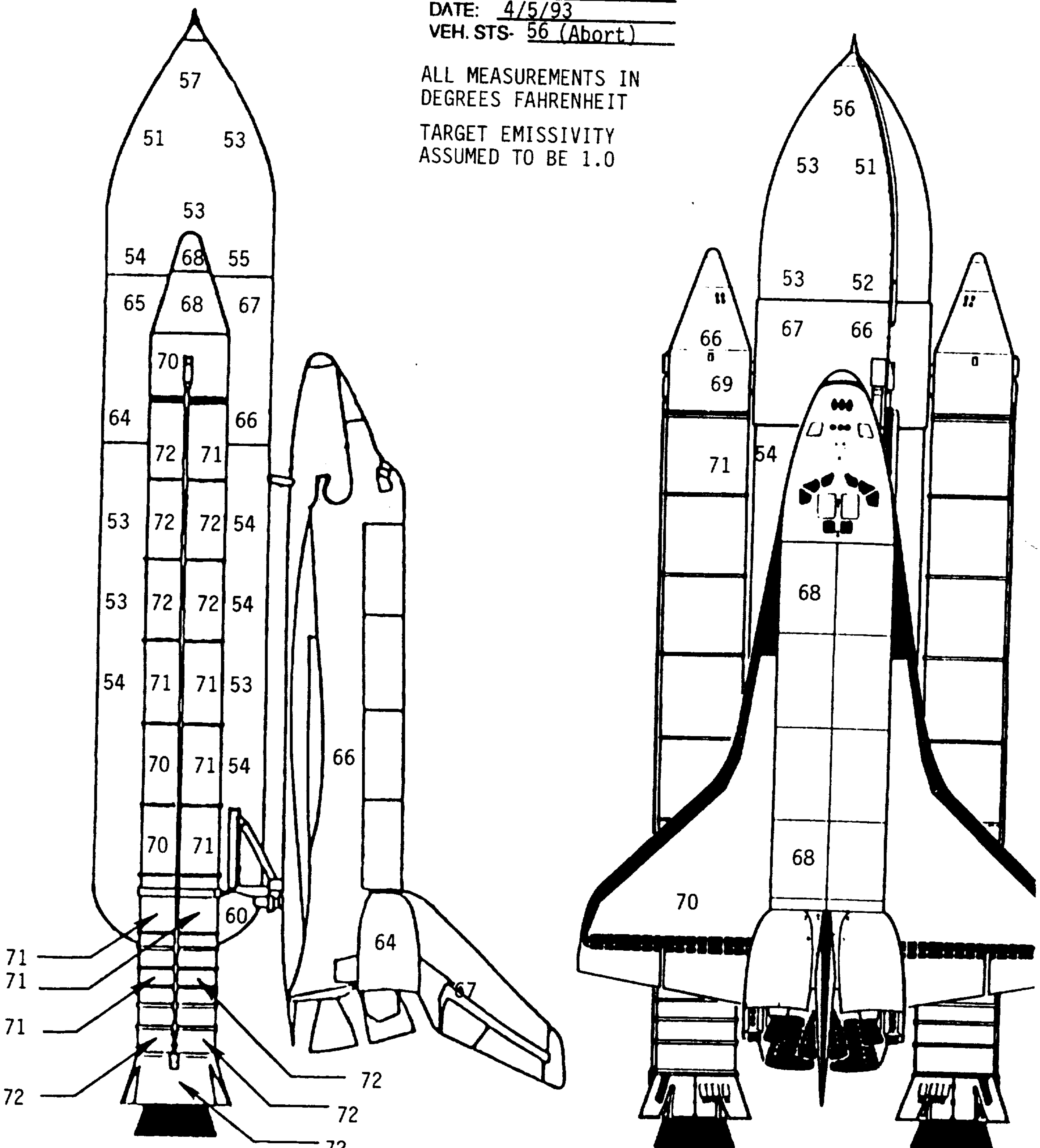


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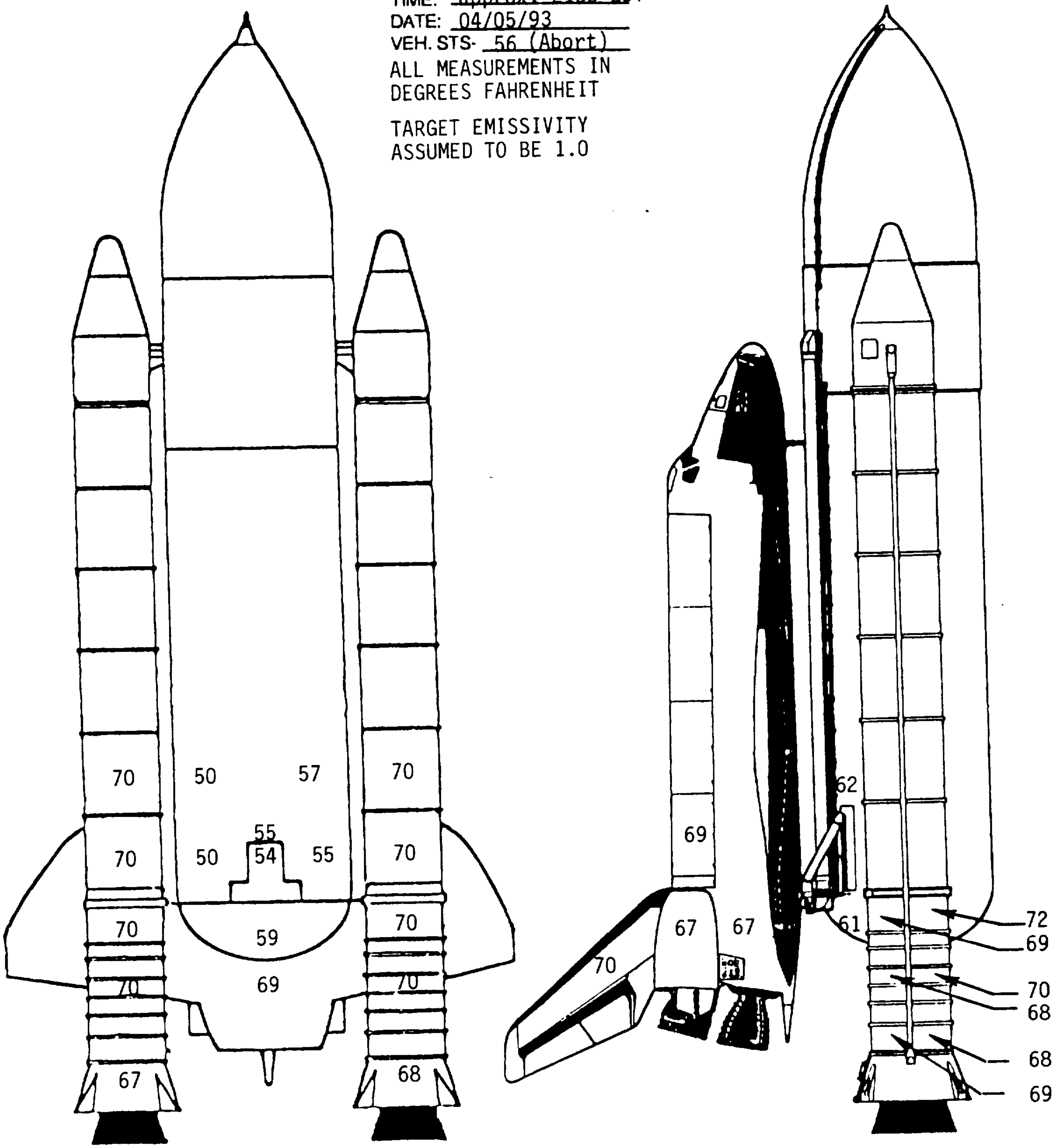
FIGURE 2. **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**

TIME: approx. 2100 EDT
DATE: 04/05/93
VEH. STS- 56 (Abort)
ALL MEASUREMENTS IN DEGREES FAHRENHEIT

TARGET EMISSIVITY ASSUMED TO BE 1.0



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3.4 EXTERNAL TANK

The ice/frost prediction computer program 'SURFICE' was run from 1730 to 0215 hours and the results tabulated in Figure 3. The program predicted condensate with no ice/frost accumulation on the TPS acreage surfaces during cryoload.

There was no condensate or ice/frost accumulations on the LO2 tank ogive. Some light condensate was present on the LO2 tank barrel section. There were no TPS anomalies. The tumble valve cover was intact. The pressurization line and support ramps were in nominal configuration. The portable STI measured surface temperatures that averaged 56 degrees F on the ogive and 53 degrees F on the barrel section. In comparison, the Cyclops radiometer measured temperatures that averaged 56 degrees F on the ogive and 52 degrees F on the barrel; SURFICE predicted temperatures of 58 degrees F on the ogive and 52 degrees F on the barrel.

The intertank acreage TPS was dry. No frost spots appeared in the stringer valleys at the LH2 and LO2 tank-to-intertank flanges. Typical ice/frost accumulations and no unusual vapors were present on the ET umbilical carrier plate. The portable STI measured an average surface temperature of 66 degrees F on the intertank; the Cyclops measured 65 degrees F.

There were no LH2 tank TPS acreage anomalies. Light condensate, but no ice or frost, was present on the acreage and aft dome. In spite of the ambient weather conditions, an ice/frost line formed along the edge of the LH2 tank PAL ramp and three of the cable tray ramp aft edges. The portable STI measured surface temperatures that averaged 53 degrees F on the upper LH2 tank and 56 degrees F on the lower LH2 tank. In comparison, the Cyclops radiometer measured temperatures that averaged 53 degrees F on the upper and 57 degrees on the lower LH2 tank, respectively; SURFICE predicted temperatures of 45 degrees F on the upper LH2 tank and 52 degrees F on the lower LH2 tank.

Some ice/frost had formed in the ET/SRB cable tray-to-upper strut fairing expansion joints. A 6-inch crack with some ice/frost accumulation was present in the +Y thrust strut-to-longeron interface. A 10-12 inch long by 1/4-inch wide crack was visible in the -Y vertical strut cable tray forward surface TPS near the longeron closeout interface. The crack exhibited no offset and was not filled with ice or frost. The appearance of the crack was expected due to the elimination of the stress relief gap at the factory. Ice/frost on a 3-inch crack in the +Z siphon manhole cover closeout was melting at the time of the Ice Inspection.

Typical amounts of ice/frost were present in the LO2 feedline bellows and support brackets.

STS- 56	TEST S0007 ABORT - High Point Bleed Valve																	DATE: 6 April 1993			T-0 TIME: DATE:			NASA KSC Ice/Frost/Debris Team	
ORBITER 103	ET 54	SRB BI-058	MLP 1	PAD B	LO2 CHILLDOWN TIME: 17:20 SLOW FILL TIME: 17:45				FAST FILL TIME: 17:57 REPLENISH TIME: 20:47						LH2 CHILLDOWN TIME: 17:24 SLOW FILL TIME: 17:32				FAST FILL TIME: 18:22 REPLENISH TIME: 20:37						
	CONDITIONS					LO2 TANK STA 370 TO 540					LO2 TANK STA 550 TO 852					LH2 TANK STA 1130 TO 1380					LH2 TANK STA 1380 TO 2058				
TIME (EDT)	TEMP F	REL HUM. %	DEW PT F	WIND VEL KNTS	WIND DIR DEG	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR
1730	80.40	51.4	61.56	20	225	II	11.80	70.35	0.0000	-0.3754	II	11.80	65.03	0.0000	-0.3426	II	6.40	59.50	0.0011	-0.1857	II	27.20	71.46	0.0000	-0.7571
1745	80.40	51.2	61.45	12	219	II	7.08	66.67	0.0000	-0.2404	II	7.08	60.59	0.0005	-0.2096	II	3.84	55.71	0.0019	-0.1110	II	16.32	67.34	0.0000	-0.4608
1800	79.80	51.6	61.09	18	222	II	10.62	69.04	0.0000	-0.3354	II	10.62	63.39	0.0000	-0.3032	II	5.76	58.26	0.0014	-0.1631	II	24.48	70.12	0.0000	-0.6706
1815	79.00	52.6	60.85	17	226	II	10.03	67.87	0.0000	-0.3135	II	10.03	62.03	0.0000	-0.2816	II	5.44	57.36	0.0016	-0.1505	II	23.12	68.92	0.0000	-0.6239
1830	79.00	54.0	61.58	14	239	II	8.26	66.53	0.0000	-0.2694	II	8.26	60.89	0.0005	-0.2380	II	4.48	56.35	0.0020	-0.1261	II	19.04	67.38	0.0000	-0.5263
1845	78.00	54.8	61.02	17	232	II	10.03	66.94	0.0000	-0.3101	II	10.03	61.10	0.0000	-0.2783	II	5.44	57.00	0.0018	-0.1480	II	23.12	67.98	0.0000	-0.6181
1900	78.00	56.2	61.72	16	238	II	9.44	66.55	0.0000	-0.2991	II	9.44	61.22	0.0004	-0.2673	II	5.12	56.98	0.0021	-0.1420	II	21.76	67.52	0.0000	-0.5932
1915	77.60	55.2	60.83	20	253	II	11.80	67.65	0.0000	-0.3545	II	11.80	62.38	0.0000	-0.3220	II	8.60	59.58	0.0009	-0.2317	II	24.20	67.93	0.0000	-0.6396
1930	75.60	55.4	59.00	14	249	II	8.26	63.15	0.0000	-0.2391	II	8.26	57.95	0.0007	-0.2085	II	6.02	55.42	0.0017	-0.1467	II	16.94	63.06	0.0000	-0.4174
1945	74.00	56.4	57.94	17	254	II	10.03	62.98	0.0000	-0.2691	II	10.03	57.64	0.0002	-0.2382	II	7.31	55.35	0.0014	-0.1680	II	20.57	63.19	0.0000	-0.4794
2000	73.00	55.4	56.48	15	247	II	8.85	61.05	0.0000	-0.2274	II	8.85	55.75	0.0005	-0.1973	II	4.80	50.96	0.0019	-0.0987	II	20.40	62.12	0.0000	-0.4497
2015	71.40	55.6	55.03	14	258	II	8.26	58.94	0.0000	-0.1993	II	8.26	53.84	0.0007	-0.1697	II	6.02	51.14	0.0016	-0.1161	II	16.94	59.00	0.0000	-0.3482
2030	70.60	56.6	54.74	14	256	II	8.26	58.16	0.0000	-0.1945	II	8.26	53.32	0.0008	-0.1650	II	6.02	50.58	0.0017	-0.1123	II	16.94	58.22	0.0000	-0.3401
2045	69.60	57.6	54.25	14	254	II	8.26	57.20	0.0000	-0.1878	II	8.26	52.59	0.0009	-0.1585	II	6.02	49.78	0.0018	-0.1070	II	16.94	57.27	0.0000	-0.3287
2100	66.60	55.2	52.60	16	265	II	9.44	57.51	0.0000	-0.1988	II	9.44	52.12	0.0002	-0.1706	II	6.88	49.54	0.0013	-0.1156	II	19.38	57.81	0.0000	-0.3543
2115	68.00	55.6	51.73	11	262	II	6.49	53.64	0.0000	-0.1347	II	6.49	48.91	0.0011	-0.1064	II	4.73	45.80	0.0018	-0.0678	II	13.31	53.42	0.0000	-0.2287
2130	67.80	56.2	51.83	12	258	II	7.08	54.17	0.0000	-0.1467	II	7.08	48.46	0.0010	-0.1173	II	5.16	46.30	0.0017	-0.0757	II	14.52	54.07	0.0000	-0.2505
2145	66.80	56.2	50.86	11	252	II	6.49	52.47	0.0000	-0.1271	II	6.49	47.84	0.0012	-0.0980	II	4.73	44.48	0.0018	-0.0617	II	13.31	52.25	0.0000	-0.2180
2200	66.20	57.4	50.85	11	248	II	6.49	51.80	0.0000	-0.1248	II	6.49	47.54	0.0013	-0.0989	II	4.73	44.14	0.0019	-0.0580	II	13.31	51.88	0.0000	-0.2125
2215	64.80	59.6	50.52	12	247	II	7.08	51.26	0.0000	-0.1291	II	7.08	47.25	0.0014	-0.1011	II	3.84	41.10	0.0021	-0.0580	II	16.32	52.30	0.0000	-0.2528
2230	64.40	61.0	50.76	12	256	II	7.08	50.91	0.0000	-0.1286	II	7.08	47.18	0.0015	-0.1005	II	5.16	43.88	0.0021	-0.0619	II	14.52	50.85	0.0000	-0.2221
2245	64.20	61.8	50.92	12	249	II	7.08	50.83	0.0000	-0.1286	II	7.08	47.16	0.0016	-0.1004	II	5.16	43.84	0.0021	-0.0618	II	14.52	50.81	0.0001	-0.2220
2300	64.20	61.8	50.92	12	249	II	7.08	50.83	0.0000	-0.1286	II	7.08	47.16	0.0016	-0.1004	II	5.16	43.84	0.0021	-0.0618	II	14.52	50.81	0.0001	-0.2220
2315	54.00	64.8	42.25	12	242	II	7.08	41.31	0.0003	-0.0598	II	7.08	37.29	0.0015	-0.0333	II	3.84	31.02	0.0019	0.0063	II	16.32	42.08	0.0001	-0.1234
2330	63.80	66.2	52.40	13	243	II	7.67	51.74	0.0003	-0.1440	II	7.67	48.32	0.0019	-0.1155	II	4.16	42.33	0.0025	-0.0486	II	17.68	52.28	0.0001	-0.2855
2345	63.30	67.4	52.41	11	246	II	6.49	50.80	0.0007	-0.1207	II	6.49	46.88	0.0022	-0.0926	II	3.52	40.26	0.0025	-0.0334	II	14.96	51.35	0.0010	-0.2354
0000	63.40	69.6	53.38	13	240	II	7.67	52.09	0.0007	-0.1470	II	7.67	48.67	0.0023	-0.1184	II	4.16	42.63	0.0027	-0.0481	II	17.68	52.65	0.0008	-0.2919
0015	62.60	71.0	53.14	12	243	II	7.08	51.25	0.0009	-0.1321	II	7.08	47.57	0.0025	-0.1036	II	3.84	41.18	0.0028	-0.0393	II	16.32	51.83	0.0013	-0.2606
0030	61.80	73.6	53.34	14	242	II	8.26	51.61	0.0010	-0.1512	II	8.26	48.35	0.0026	-0.1225	II	4.48	42.42	0.0030	-0.0495	II	19.04	52.23	0.0013	-0.3035
0045	61.50	76.0	53.92	12	241	II	7.08	51.16	0.0013	-0.1315	II	7.08	47.46	0.0029	-0.1030	II	3.84	40.96	0.0030	-0.0384	II	16.32	51.81	0.0022	-0.2603
0100	61.80	78.2	55.00	13	242	II	7.67	52.26	0.0015	-0.1487	II	7.67	48.82	0.0031	-0.1198	II	4.16	42.60	0.0033	-0.0482	II	17.68	52.91	0.0024	-0.2967
0115	61.40	80.2	55.30	12	245	II	7.08	51.90	0.0017	-0.1374	II	7.08	48.23	0.0033	-0.1087	II	3.84	41.68	0.0033	-0.0417	II	16.32	52.58	0.0029	-0.2725
0130	61.00	81.6	55.38	9	243	II	5.31	50.37	0.0019	-0.1025	II	5.31	45.75	0.0033	-0.0744	II	2.88	38.15	0.0031	-0.0221	II	12.24	51.03	0.0035	-0.1970
0145	60.60	83.4	55.59	11	247	II	6.49	51.29	0.0020	-0.1246	II	6.49	47.33	0.0035	-0.0961	II	3.52	40.42	0.0034	-0.0342	II	14.96	52.00	0.0035	-0.2455
0200	60.00	85.0	55.51	13	244	II	7.67	51.71	0.0021	-0.1443	II	7.67	48.25	0.0036	-0.1154	II	4.16	41.86	0.0036	-0.0447	II	17.68	52.44	0.0035	-0.2894
0215	59.80	86.4	55.76	10	248	II	5.90	50.53	0.0022	-0.1114	II	5.90	46.25	0.0037	-0.0831	II	4.30	42.25	0.0037	-0.0475	II	12.10	50.65	0.0040	-0.1909
AVG.	68.24	63.12	55.05	13.50	WSW		7.97	56.52				7.97	51.99				4.93	47.35				17.53	56.98		

Period of Ice Team inspection

FIGURE 3. "SURFICE" Computer Predictions

There were no TPS anomalies on the LO2 ET/ORB umbilical. The purge barrier (baggie) was configured properly and was holding positive purge pressure. There were no accumulations of ice or frost on the acreage areas of the umbilical. Formation of ice/frost on the separation bolt pyrotechnic canister purge vents was typical. Normal venting of nitrogen purge gas had occurred during tanking, stable replenish, and launch.

Ice/frost in the LH2 recirculation line bellows and on both burst disks was typical. The LH2 feedline bellows were wet with condensate.

Less than usual amounts of ice/frost had accumulated on the top, aft, and outboard sides of the LH2 ET/ORB umbilical purge barrier. Typical ice/frost fingers had formed on the pyro canister and plate gap purge vents. Light ice/frost accumulations were present around the aft pyrotechnic canister closeout due to the thin TPS closeout. A typical ice/frost ring had formed on the cable tray vent hole. The 17-inch flapper valve actuator access port foam plug was properly closed out and exhibited no blowing purge gas leaks or ice/frost formations. No unusual vapors or cryogenic drips had appeared during tanking, stable replenish, and launch.

The ET/ORB hydrogen detection sensor tygon tubing was in proper position prior to removal. The tubing was successfully removed from the vehicle without contacting Orbiter tiles.

The summary of Ice/Frost Team observations/anomalies consisted of six OTV recorded items:

Anomaly 001 documented a 10-12 inch long by 1/4-inch wide crack in the -Y vertical strut cable tray forward surface near the longeron closeout interface. The crack exhibited no offset and was not filled with ice or frost. The condition was acceptable for launch per NSTS-08303 and CR S041254C.

Anomaly 002 documented ice/frost lines along the LH2 tank PAL ramp perimeter and three of the cable tray ramp aft edges. The ice/frost lines were acceptable per NSTS-08303.

Anomaly 003 documented a 6-inch crack with some ice and frost accumulation in the +Y thrust strut-to-longeron interface. The crack with ice/frost was acceptable per NSTS-08303.

Anomaly 004 documented a 3-inch crack with ice and frost accumulation on the aft dome +Z manhole cover closeout ring. The condition was acceptable per the NSTS-08303 criteria.
Anomaly 005 (documentation only) recorded ice/frost formations on the ET/ORB LH2 and LO2 umbilicals. The formations were acceptable per the NSTS-08303 criteria.

Anomaly 006 (documentation only) recorded ice/frost formations in the LO2 feedline bellows and support brackets. The ice/frost formations were acceptable per NSTS-08303.

Three more observations/anomalies were added during post drain surveillance:

Anomaly 007 documented two ice/frost formations on the aft side of the +Y vertical strut cable tray: at the drain hole and at the ET acreage interface. No TPS damage was apparent.

Anomaly 008 documented an ice/frost formation on the aft dome apex closeout (+Y side of the NCFI interface). Additional ice and frost formations occurred at the NCFI interface -Y side. No TPS damage was apparent.

Anomaly 009 documented vapors emanating from an area behind the -Y vertical strut cable tray (between the cable tray and the LH2 tank). No TPS damage was apparent.

3.5 FACILITY

All SRB sound suppression water troughs were filled and properly configured for launch. There was no debris on the MLP deck or in the SRB holddown post areas.

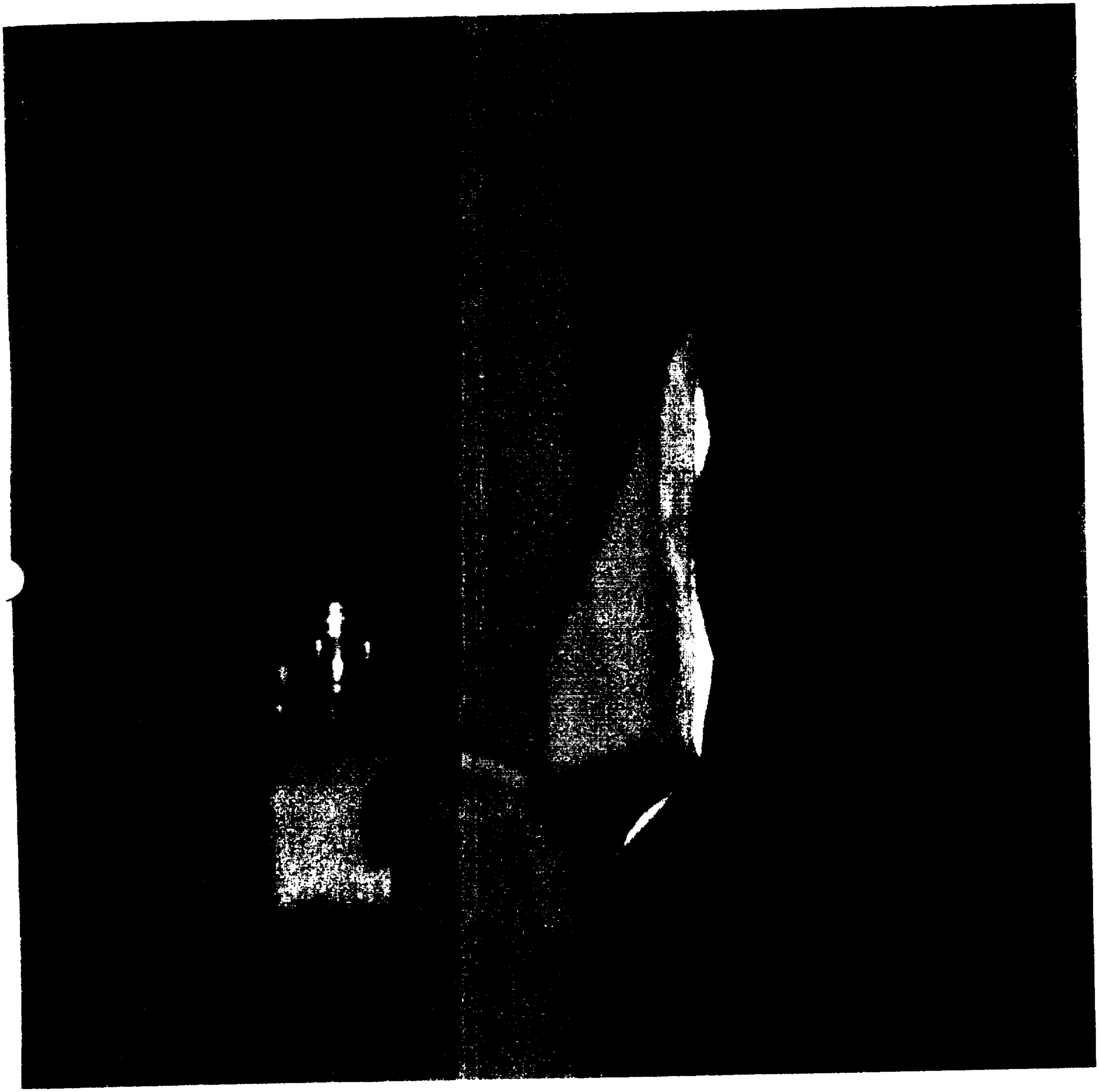
No leaks were observed on either the LO2 or LH2 Orbiter T-0 umbilicals. Typical amounts of ice/frost had formed on the cryogenic lines and purge shrouds.

There was no apparent hydrogen leakage anywhere on the GH2 vent line or GUCP. Some ice and frost, which was expected, had accumulated on the GUCP legs and on the uninsulated parts of the umbilical carrier plate.

Visual and infrared observations of the GOX seals confirmed no leakage. No ET nosecone/footprint damage was visible after the GOX vent hood was retracted. No icicles had formed on the north or south GOX vent ducts.

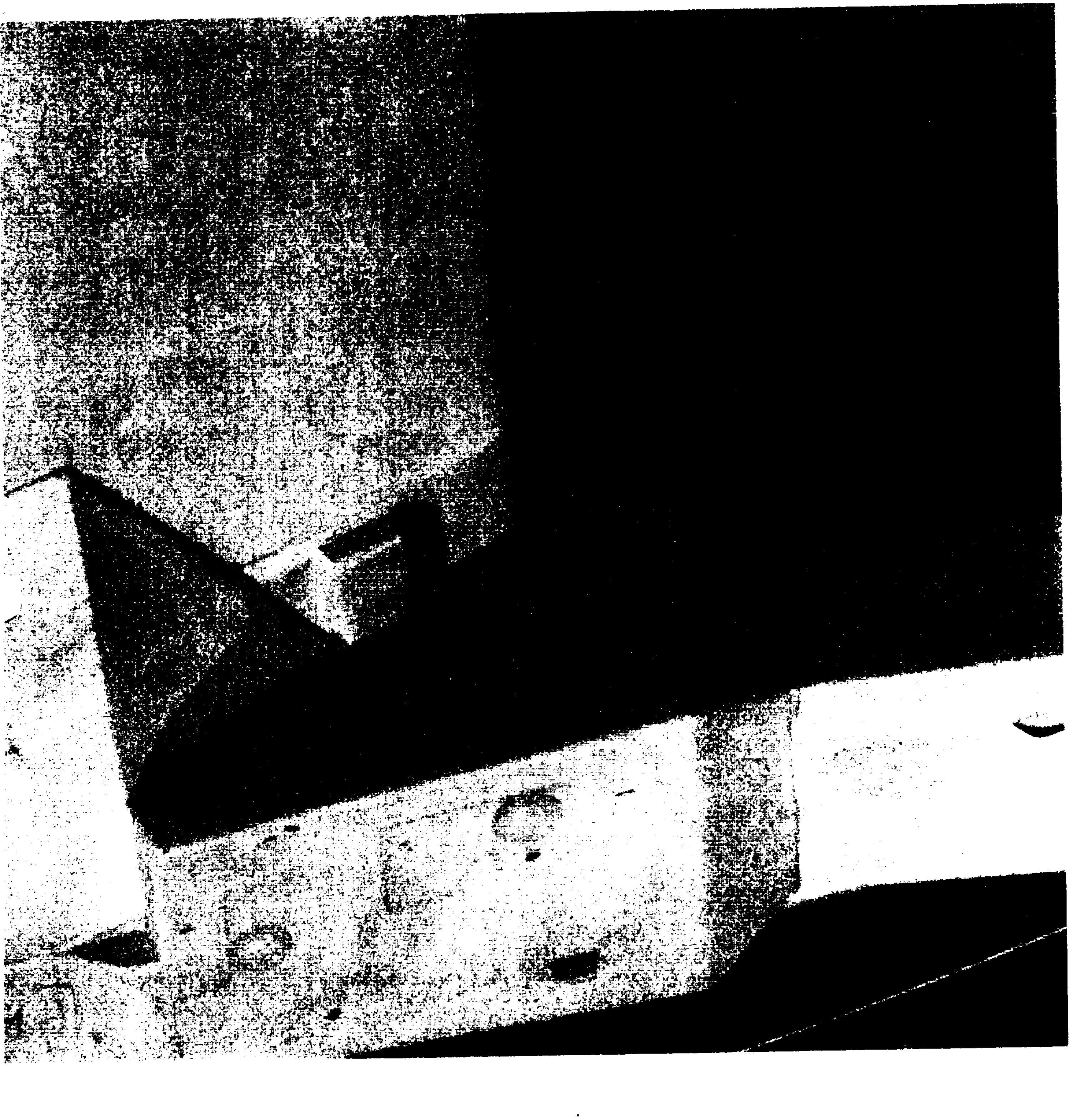
In spite of the warm ambient weather conditions, an ice/frost line formed along the edge of the LH2 tank PAL ramp. There was no ice or frost accumulation on the LH2 tank acreage TPS.

ORIGINAL PAGE
COLOR PHOTOGRAPH



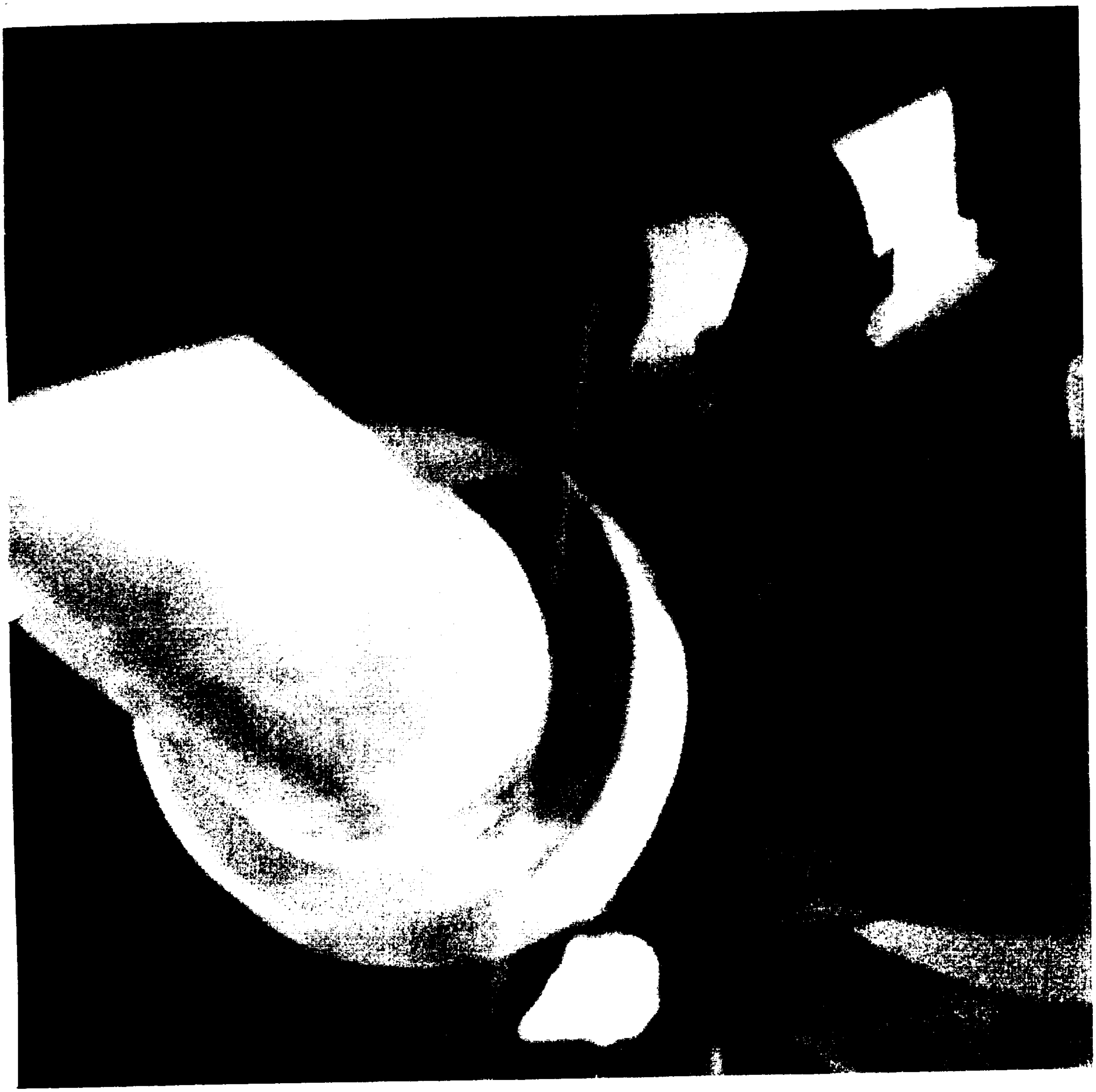
In spite of the warm ambient weather conditions, ice/frost had formed along the edges of three cable tray support ramps.

ORIGINAL PAGE
COLOR PHOTOGRAPH



A 10-12 inch long crack occurred in the -Y vertical strut cable tray forward surface TPS near the longeron closeout interface. The 1/4-inch wide crack exhibited no offset and was not filled with ice or frost. The condition was acceptable for flight.

Less than usual amounts of ice/frost had formed on the ET/ORB LH2 umbilical. No unusual vapors or cryogenic drips had appeared during tanking, stable replenish, and launch.



The 17-inch flapper valve actuator access port TPS plug was properly closed out and exhibited no blowing purge gas leaks or ice/frost formations.

3.6 POST DRAIN VEHICLE INSPECTION

The launch of STS-56 was aborted due to a problem with the MPS LH2 high point bleed valve instrumentation. A post drain inspection of the vehicle was performed at Pad-39B from 0930 to 1130 hours on 6 April 1993.

There were no Orbiter anomalies. SSME's and T-0 umbilicals appeared to be in nominal configuration. All RCS thruster paper covers were intact. No tile damage was observed.

There was no visible damage on the External Tank nosecone, fairing, or foot print area. No significant amounts of topcoat were missing. The tumble valve cover was intact.

No anomalies (divots or cracks) were observed on the LO2 tank, intertank, or LH2 tank acreage.

Ice remained in the LO2 feedline support brackets, but no loose foam or TPS damage was visible. Ice in the feedline bellows had melted.

Bipod jack pad closeouts were intact and flush with adjacent LH2 tank-to-intertank flange closeout foam.

The crack in the +Y thrust strut-to-longeron interface TPS closeout observed during the Ice Inspection was still visible. A very small crack was present in the -Y thrust strut-to-longeron interface.

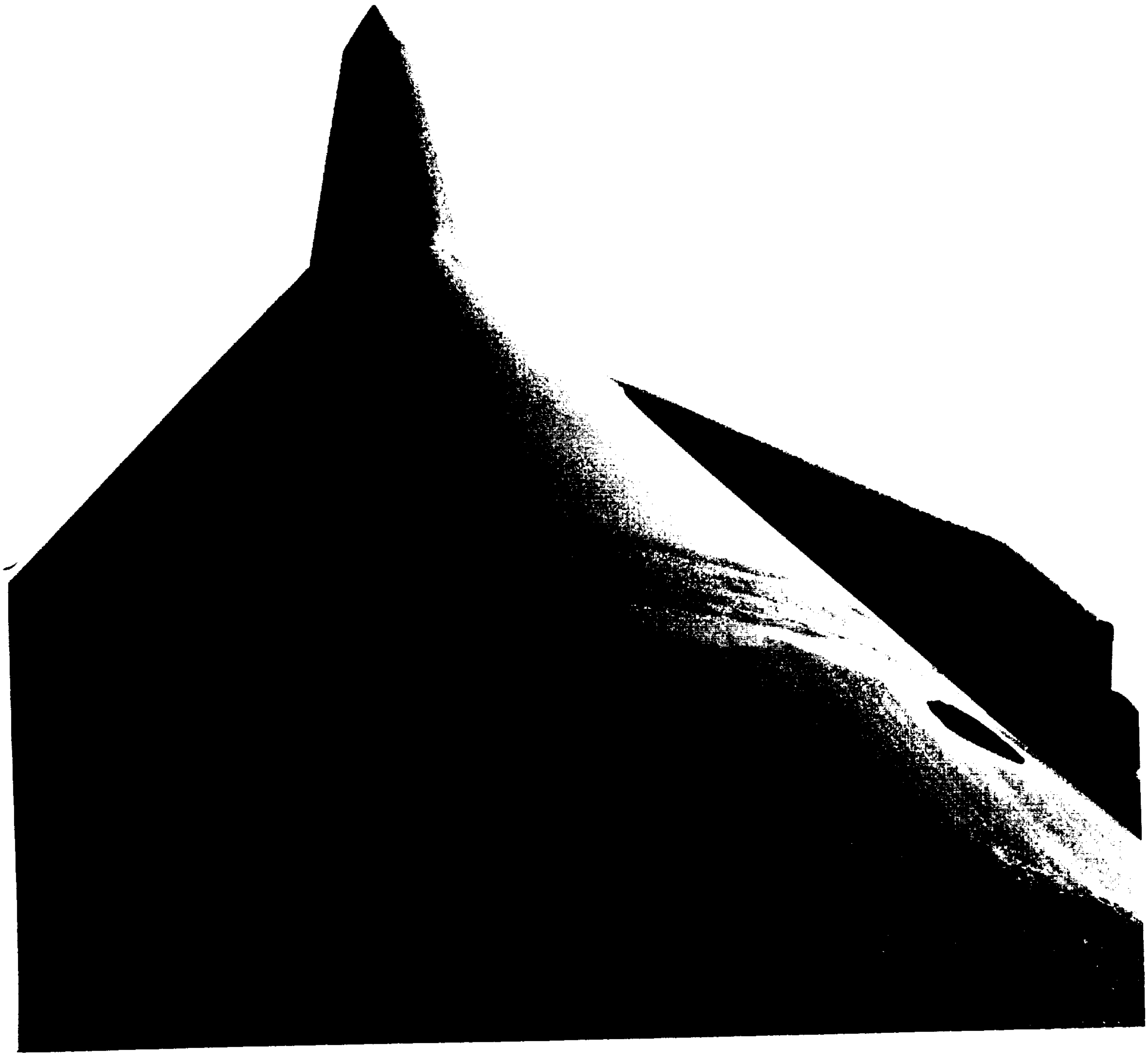
The 12-inch crack in the -Y ET/SRB vertical strut cable tray forward surface TPS (reported during the Ice Inspection) was still visible.

A 6-inch crack was present at the +Y vertical strut cable tray-to-tank interface (aft side). A 3-inch diameter ice formation was observed in this location during the Ice Inspection.

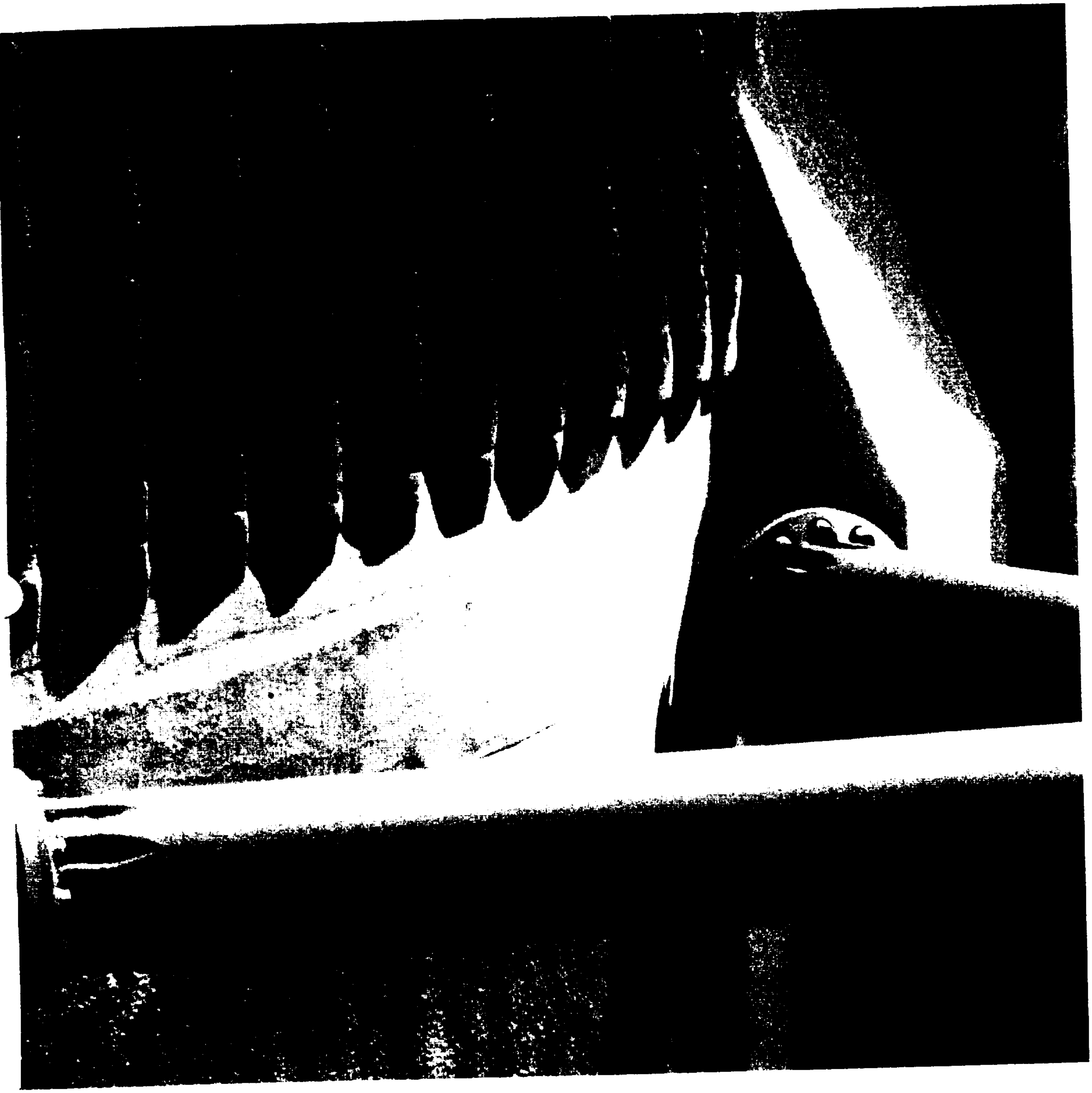
Two cracks, both 3-4 inches in length, were located in the aft dome +Z siphon manhole cover BX-250 closeout near the leak check plug closeout.

No SRB anomalies were observed. IPR 56V-0105 was taken earlier in the countdown against marks on the LH SRB forward center segment near the field joint closeout. Under daylight conditions, the marks appeared to be grease (similar to the grease used in field joint closeouts), and dark scuff marks. No paint appeared to be missing and no metal was exposed.

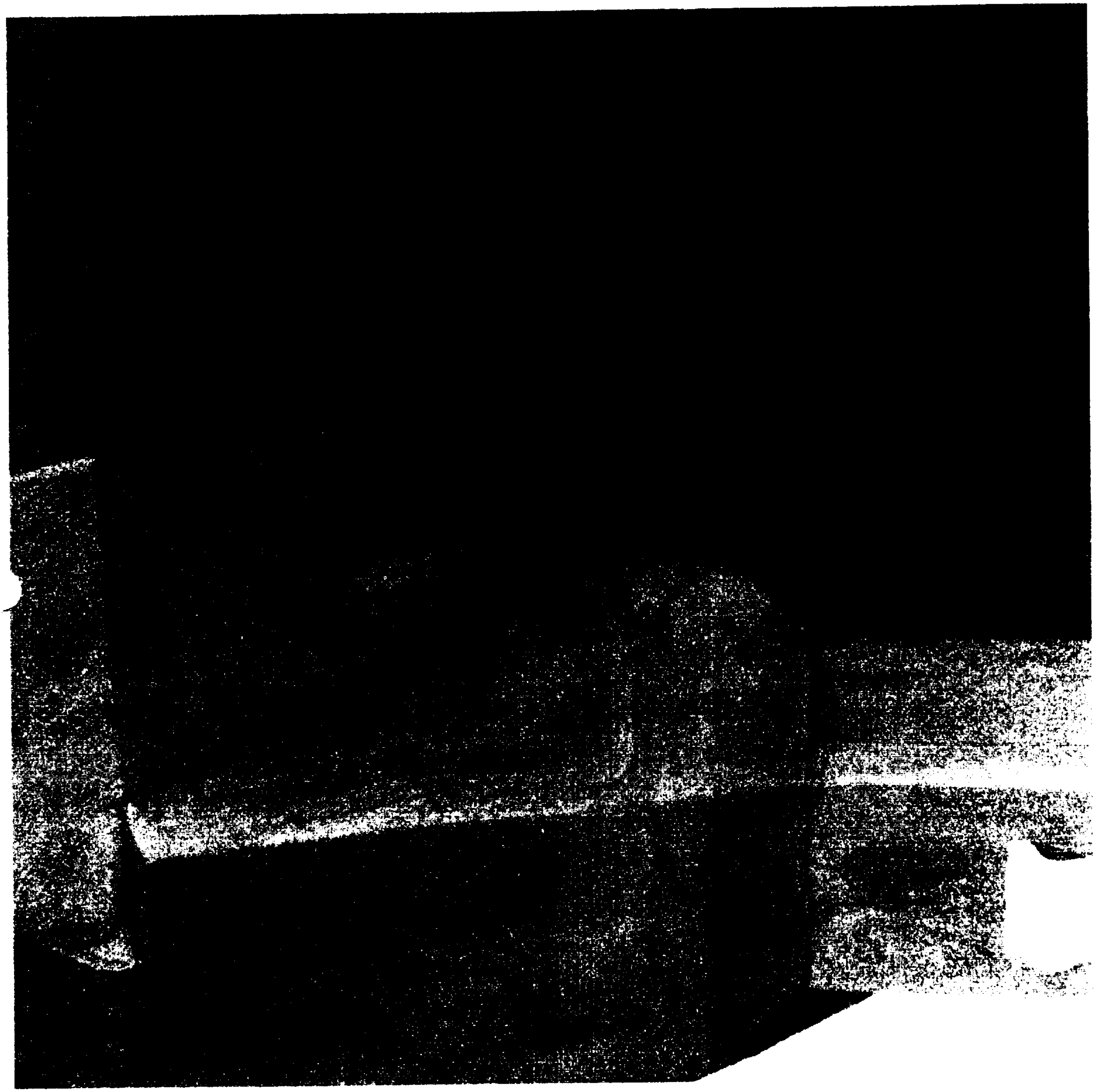
No MLP deck or launch pad anomalies were observed. No IPR's were generated as a result of this inspection and all TPS anomalies were acceptable for the next launch attempt per the NSTS-08303 criteria. A hands-on inspection of the LO2 feedline brackets was not performed due to the 48 hour turnaround.



There was no visible damage on the nosecone, fairing, or foot print area. No significant amounts of topcoat were missing. The tumble valve cover was intact.



Bipod jack pad closeouts were intact and flush with adjacent LH2 tank-to-intertank flange closeout foam



The 12-inch crack in the -Y vertical strut cable tray forward surface TPS was still visible after the tank had been drained.

4.0 LAUNCH

STS-56 was launched at 8:05:28:59.986 GMT (01:29 a.m. local) on 8 April 1993.

4.1 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 7 April 1993 from 2010 to 2238 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no Launch Commit Criteria, OMRS, or NSTS-08303 violations. One IPR was taken by CLHY against a GH2 vent line hydrogen leak. There were no conditions outside of the established data base. Ambient weather conditions at the time of the inspection were:

Temperature:	65.2 Degrees F
Relative Humidity:	79.2 Percent
Wind Speed:	12.3 Knots
Wind Direction:	5 Degrees

A portable Shuttle Thermal Imager (STI) infrared scanning radiometer was utilized to obtain vehicle surface temperature measurements for an overall thermal assessment of the vehicle, as shown in Figures 4 and 5.

4.2 ORBITER

No Orbiter tile or RCC panel anomalies were observed. All water spray boiler plugs and RCS thruster paper covers were intact, though the R2U and R3R covers on the aft RCS stinger had been wetted by vapors. Typical ice/frost accumulations were present at the SSME #1 and #2 heat shield-to-nozzle interfaces. Condensate was present on the SSME #1 and #2 heat shields, but the base heat shield tiles were dry. An infrared scan revealed no unusual temperature gradients on the base heat shield or engine mounted heat shields. No unusual vapors originated from inside the SSME nozzles.

4.3 SOLID ROCKET BOOSTERS

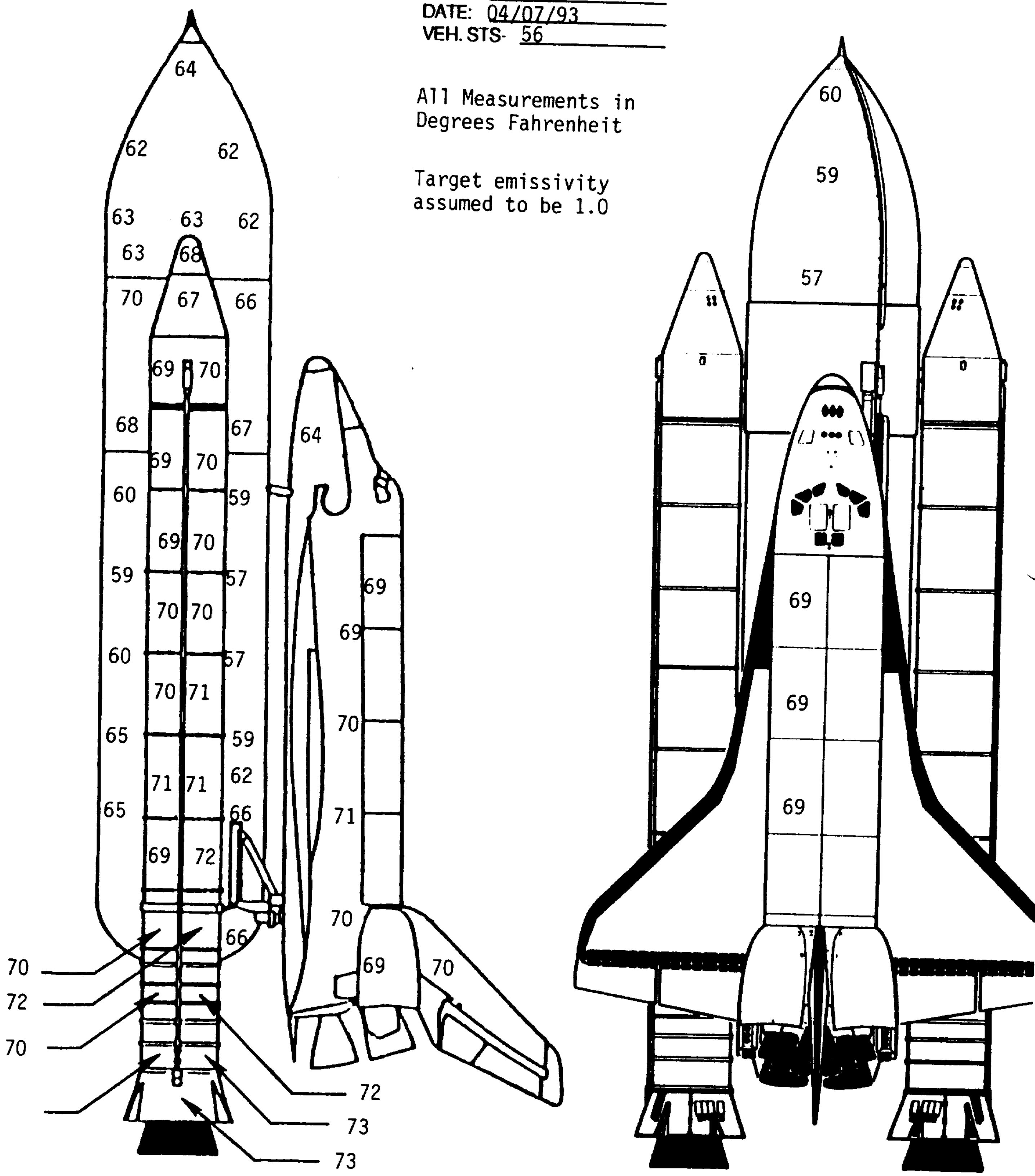
No SRB anomalies or loose ablator/cork were observed. The K5NA closeouts of the aft booster stiffener ring splice plates were intact. The STI portable infrared scanner recorded RH and LH SRB case temperatures between 67 and 71 degrees Fahrenheit (F). In comparison, temperatures measured by a hand-held Minolta/Land Cyclops spot radiometer ranged from 65 to 67 degrees F and the SRB Ground Environment Instrumentation (GEI) measured temperatures ranging from 65 to 67 degrees F. All measured temperatures were above the 34 degrees F minimum requirement. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 68 degrees F, which was within the required range of 44-86 degrees F

FIGURE 4. **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**

TIME: approx. 2000 EDT
DATE: 04/07/93
VEH. STS- 56

All Measurements in Degrees Fahrenheit

Target emissivity assumed to be 1.0



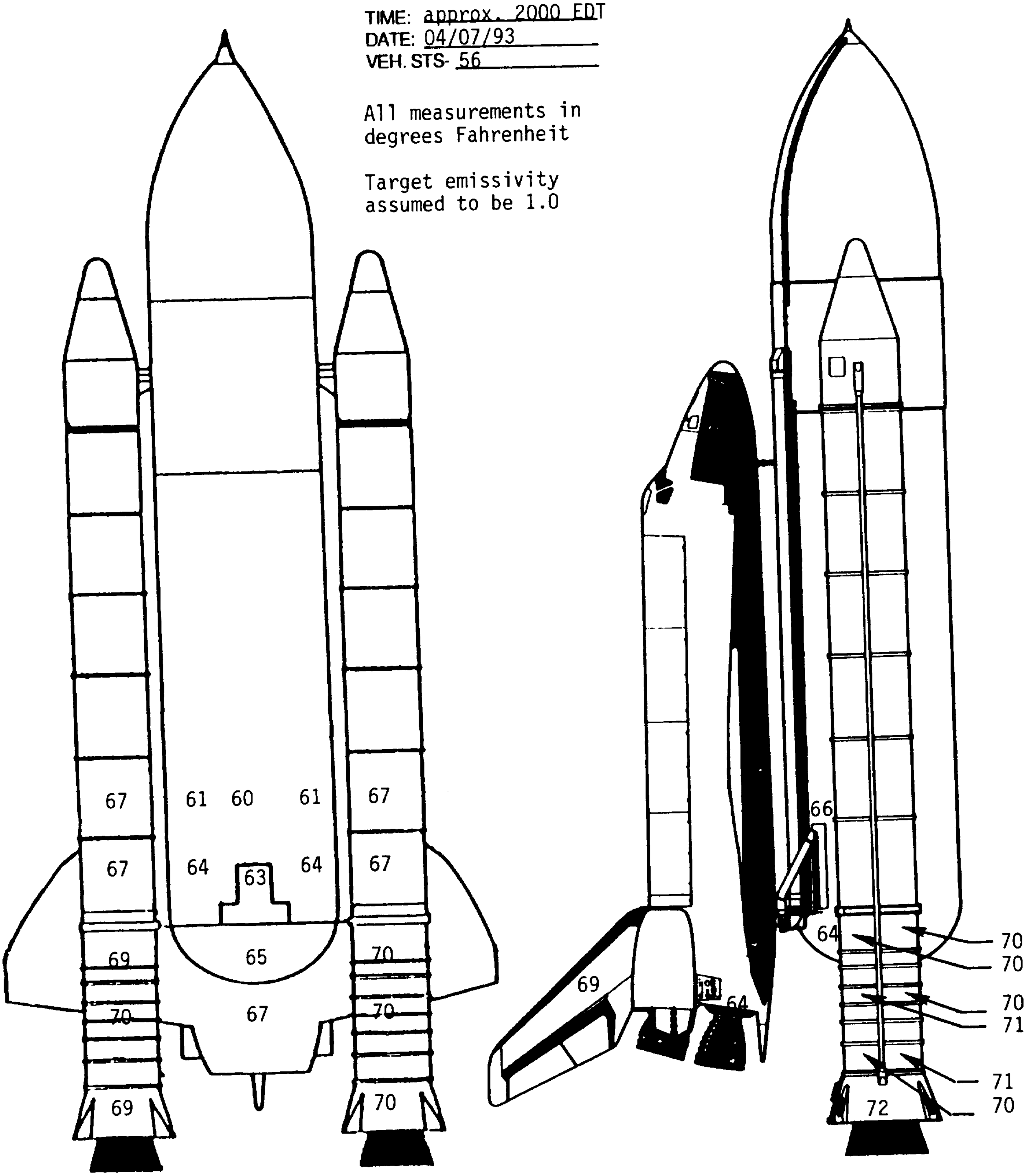
EGG/V-343D

FIGURE 5. **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**

TIME: approx. 2000 EDT
DATE: 04/07/93
VEH. STS- 56

All measurements in degrees Fahrenheit

Target emissivity assumed to be 1.0



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4.4 EXTERNAL TANK

The ice/frost prediction computer program 'SURFICE' was run from 1730 to 0130 hours and the results tabulated in Figure 6. The program predicted condensate with no ice/frost accumulation on the TPS acreage surfaces during cryoload.

There was light condensate, but no ice/frost accumulations, on the LO2 tank. There were no TPS anomalies. The tumble valve cover was intact. The portable STI measured surface temperatures that averaged 64 degrees F on the ogive and 62 degrees F on the barrel section. In comparison, the Cyclops radiometer measured temperatures that averaged 58 degrees F on the ogive and 56 degrees F on the barrel; SURFICE predicted temperatures of 56 degrees F on the ogive and 53 degrees F on the barrel.

No frost spots appeared in the intertank stringer valleys at the LH2 and LO2 tank-to-intertank flanges. Typical ice/frost accumulations and no unusual vapors were present on the ET umbilical carrier plate. The portable STI measured an average surface temperature of 67 degrees F on the intertank compared to 64 degrees as measured by the Cyclops radiometer.

There were no LH2 tank TPS acreage anomalies. Light condensate, but no ice or frost, was present on the acreage and aft dome. The portable STI measured surface temperatures that averaged 58 degrees F on the upper LH2 tank and 62 degrees F on the lower LH2 tank. In comparison, the Cyclops radiometer measured temperatures that averaged 56 degrees F on both the upper and lower LH2 tank; SURFICE predicted temperatures of 50 degrees F on the upper LH2 tank and 55 degrees F on the lower LH2 tank.

There were no anomalies on the bipod jack pad closeouts. Two pressurization line ramps exhibited ice/frost along the ramp to ET acreage interface. Some ice/frost was present in the ET/SRB cable tray-to-upper strut fairing expansion joints.

Six-inch cracks with some ice/frost accumulation were present in both the -Y and +Y thrust strut-to-longeron interfaces. A 4-inch crack along the aft edge of the -Y vertical strut cable tray TPS had not changed since the first cryoload. Two 3-inch cracks in the +Z siphon manhole cover closeout had not changed.

A 12 inch long crack in the -Y vertical strut cable tray forward surface TPS near the longeron closeout interface (previously observed during the first cryoload) had increased in length. A 4-inch crack, propagating outboard from the ET interface, was most likely a continuation of the forward surface 12-inch crack along the inboard side of the vertical strut/cable tray. The 4-inch crack exhibited some offset, which was caused by structural deflection rather than a TPS debond. The appearance of the crack was expected due to the elimination of the stress relief gap at the factory and was acceptable for flight per the NSTS-08303 criteria.

STS- 56 | TEST S0007 LAUNCH | DATE: 8 April 1993 | T-0 TIME: 01:28:59 EDT DATE: 4/8/93 | NASA KSC Ice/Frost/Debris Team

ORBITER 103 | ET 54 | SRB BI-058 | MLP 1 | PAD B

LO2 — CHILLDOWN TIME: 16:58 SLOW FILL TIME: 17:19 FAST FILL TIME: 17:32 REPLENISH TIME: 19:40

LH2 — CHILLDOWN TIME: 16:40 SLOW FILL TIME: 16:54 FAST FILL TIME: 17:38 REPLENISH TIME: 19:50

TIME (EDT)	CONDITIONS					LO2 TANK STA 370 TO 540					LO2 TANK STA 550 TO 852					LH2 TANK STA 1130 TO 1380					LH2 TANK STA 1380 TO 2058				
	TEMP F	REL HUM. %	DEW PT F	WIND VEL KNTS	WIND DIR DEG	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR
1730	68.20	70.4	58.41	15	342	‖	8.85	57.63	0.0006	-0.2186	‖	8.85	54.77	0.0024	-0.1884	‖	6.60	52.20	0.0030	-0.1323	‖	14.85	56.90	0.0017	-0.3158
1745	66.60	70.8	56.99	15	348	‖	8.85	56.12	0.0006	-0.2031	‖	8.85	53.20	0.0024	-0.1732	‖	6.60	50.57	0.0030	-0.1201	‖	14.85	55.39	0.0017	-0.2927
1800	68.00	70.4	58.21	17	340	‖	10.03	57.84	0.0003	-0.2431	‖	10.03	55.25	0.0022	-0.2125	‖	7.48	52.90	0.0029	-0.1505	‖	16.83	57.21	0.0012	-0.3556
1815	66.20	71.4	56.83	14	347	‖	8.26	55.61	0.0006	-0.1879	‖	8.26	52.50	0.0025	-0.1582	‖	6.16	49.73	0.0030	-0.1067	‖	13.86	54.82	0.0020	-0.2686
1830	66.60	72.0	57.46	17	345	‖	10.03	56.80	0.0005	-0.2313	‖	10.03	54.18	0.0024	-0.2010	‖	7.48	51.78	0.0030	-0.1412	‖	16.83	56.19	0.0015	-0.3382
1845	66.80	72.0	57.65	15	342	‖	8.85	56.59	0.0007	-0.2079	‖	8.85	53.68	0.0025	-0.1779	‖	6.60	51.07	0.0031	-0.1238	‖	14.85	55.87	0.0019	-0.3001
1900	66.40	72.6	57.49	14	349	‖	8.26	56.08	0.0009	-0.1924	‖	8.26	52.99	0.0027	-0.1627	‖	6.16	50.23	0.0032	-0.1121	‖	13.86	55.30	0.0022	-0.2755
1915	66.60	73.2	57.91	13	337	‖	7.67	56.14	0.0011	-0.1827	‖	7.67	52.87	0.0028	-0.1530	‖	5.98	50.34	0.0033	-0.1107	‖	15.99	56.26	0.0019	-0.3254
1930	65.80	74.4	57.57	14	349	‖	8.26	55.87	0.0011	-0.1905	‖	8.26	52.76	0.0029	-0.1607	‖	6.16	49.98	0.0033	-0.1105	‖	13.86	55.09	0.0025	-0.2728
1945	66.40	75.2	58.46	13	343	‖	7.67	56.38	0.0013	-0.1850	‖	7.67	53.11	0.0030	-0.1552	‖	5.72	50.21	0.0034	-0.1065	‖	12.87	55.54	0.0028	-0.2629
2000	66.60	76.2	58.04	14	347	‖	8.26	56.06	0.0013	-0.1924	‖	8.26	52.95	0.0031	-0.1625	‖	6.16	50.16	0.0036	-0.1118	‖	13.86	55.29	0.0027	-0.2757
2015	65.80	76.8	58.46	11	348	‖	6.49	55.43	0.0016	-0.1562	‖	6.49	51.67	0.0032	-0.1289	‖	4.84	48.40	0.0036	-0.0848	‖	10.89	54.41	0.0032	-0.2172
2030	65.40	76.6	57.98	15	355	‖	8.85	56.19	0.0012	-0.2049	‖	8.85	53.25	0.0030	-0.1740	‖	6.60	50.58	0.0035	-0.1204	‖	14.86	56.50	0.0027	-0.2947
2045	65.80	77.2	58.59	14	356	‖	8.26	56.48	0.0014	-0.1985	‖	8.26	52.39	0.0032	-0.1665	‖	6.16	50.61	0.0036	-0.1149	‖	13.86	56.72	0.0028	-0.2819
2100	65.40	77.6	58.34	11	353	‖	6.49	55.19	0.0016	-0.1549	‖	6.49	51.41	0.0033	-0.1250	‖	4.84	48.12	0.0035	-0.0853	‖	10.89	54.16	0.0033	-0.2144
2115	65.40	78.8	58.77	15	357	‖	8.85	56.66	0.0015	-0.2089	‖	8.85	53.74	0.0033	-0.1788	‖	6.60	51.07	0.0037	-0.1241	‖	14.85	55.99	0.0030	-0.3023
2130	66.00	80.2	58.86	14	355	‖	8.26	56.29	0.0017	-0.1946	‖	8.26	53.19	0.0035	-0.1648	‖	6.16	50.37	0.0036	-0.1134	‖	13.86	55.57	0.0034	-0.2767
2145	64.80	81.2	58.60	12	360	‖	7.08	55.88	0.0019	-0.1868	‖	7.08	52.18	0.0036	-0.1391	‖	5.28	49.03	0.0036	-0.0938	‖	11.88	54.80	0.0037	-0.2378
2200	64.80	82.0	59.28	10	3	‖	5.90	55.05	0.0020	-0.1434	‖	5.90	50.98	0.0036	-0.1142	‖	4.40	47.46	0.0038	-0.0749	‖	9.90	53.93	0.0039	-0.1969
2215	65.00	82.0	59.47	11	8	‖	6.49	56.08	0.0020	-0.1586	‖	6.49	51.93	0.0037	-0.1290	‖	4.84	48.62	0.0039	-0.0862	‖	10.89	54.71	0.0039	-0.2208
2230	64.80	81.8	59.01	9	48	‖	5.31	54.28	0.0021	-0.1282	‖	6.31	49.86	0.0036	-0.0993	‖	6.30	50.45	0.0039	-0.1158	‖	10.89	54.24	0.0038	-0.2164
2245	65.00	80.0	58.79	11	49	‖	6.48	55.27	0.0018	-0.1651	‖	6.49	51.50	0.0035	-0.1258	‖	7.70	52.05	0.0038	-0.1488	‖	13.31	55.38	0.0034	-0.2674
2300	65.20	78.4	58.43	12	60	‖	7.08	55.51	0.0016	-0.1671	‖	7.08	51.99	0.0033	-0.1376	‖	8.40	52.53	0.0036	-0.1608	‖	14.52	55.59	0.0030	-0.2908
2315	65.20	77.8	58.22	12	58	‖	7.08	55.30	0.0016	-0.1660	‖	7.08	51.86	0.0033	-0.1365	‖	8.40	52.39	0.0035	-0.1595	‖	14.52	55.46	0.0029	-0.2868
2330	65.20	78.0	58.29	11	64	‖	6.49	55.06	0.0017	-0.1533	‖	6.49	51.28	0.0033	-0.1241	‖	7.70	51.83	0.0036	-0.1449	‖	13.31	55.10	0.0031	-0.2641
2345	65.00	77.2	57.81	11	69	‖	6.49	54.68	0.0016	-0.1503	‖	6.49	50.88	0.0032	-0.1212	‖	6.05	49.57	0.0035	-0.1064	‖	13.42	54.74	0.0029	-0.2611
2400	64.80	76.6	57.39	8	68	‖	4.72	52.82	0.0017	-0.1093	‖	4.72	47.95	0.0031	-0.0809	‖	4.40	46.30	0.0034	-0.0687	‖	9.76	52.67	0.0033	-0.1814
015	64.80	77.2	57.61	10	60	‖	5.90	54.04	0.0016	-0.1359	‖	5.90	49.94	0.0032	-0.1070	‖	7.00	50.51	0.0035	-0.1250	‖	12.10	54.02	0.0031	-0.2312
030	65.40	75.6	57.62	13	62	‖	7.67	55.44	0.0013	-0.1764	‖	7.67	52.13	0.0030	-0.1469	‖	9.10	52.64	0.0032	-0.1717	‖	15.73	55.53	0.0023	-0.3094
045	65.00	76.2	57.45	10	63	‖	5.90	54.04	0.0016	-0.1359	‖	5.90	49.94	0.0031	-0.1070	‖	7.00	50.51	0.0034	-0.1250	‖	12.10	54.00	0.0029	-0.2310
100	65.00	76.8	57.66	9	66	‖	5.31	53.67	0.0017	-0.1239	‖	5.31	49.23	0.0032	-0.0952	‖	6.30	49.81	0.0035	-0.1111	‖	10.89	53.56	0.0032	-0.2076
115	65.20	75.2	57.28	12	57	‖	7.08	54.83	0.0013	-0.1612	‖	7.08	51.28	0.0030	-0.1319	‖	8.40	51.81	0.0032	-0.1542	‖	14.52	54.87	0.0025	-0.2801
T-0	64.80	74.8	56.74	11	54	‖	6.49	53.96	0.0014	-0.1446	‖	6.49	50.14	0.0030	-0.1157	‖	7.70	50.69	0.0032	-0.1353	‖	13.31	53.97	0.0026	-0.2487
AVG.	65.63	76.26	58.06	12.52	NNW-NE		7.38	55.54				7.38	52.06				6.52	50.44				13.42	55.08		

Period of Ice Team Inspection

FIGURE 6. "SURFICE" Computer Predictions

Typical amounts of ice/frost were present in the LO2 feedline bellows and support brackets.

There were no TPS anomalies on the LO2 ET/ORB umbilical. The purge barrier (baggie) was configured properly and was holding positive purge pressure. There were no accumulations of ice/frost on the acreage areas of the umbilical. Formation of ice/frost on the separation bolt pyrotechnic canister purge vents was typical. Normal venting of nitrogen purge gas had occurred during tanking, stable replenish, and launch.

Ice/frost in the LH2 recirculation line bellows and on both burst disks was typical. The LH2 feedline bellows were wet with condensate and some frost was beginning to form.

Less than usual amounts of ice and frost had accumulated on the top, aft, and outboard sides of the LH2 ET/ORB umbilical purge barrier. Typical ice/frost fingers were present on the pyro canister and plate gap purge vents. A typical ice/frost ring had formed on the cable tray vent hole. No ice/frost had formed on the 17-inch flapper valve actuator access port foam plug closeout. No unusual vapors or cryogenic drips had appeared during tanking, stable replenish, and launch.

The ET/ORB hydrogen detection sensor tygon tubing had not been re-installed during the 48 hour scrub turnaround.

The summary of Ice/Frost Team observations/anomalies consisted of nine OTV recorded items:

Anomaly 001 documented a 12-inch long by 1/4-inch wide crack in the -Y vertical strut cable tray forward surface TPS near the longeron interface. The crack exhibited no offset and was not filled with ice or frost. The condition was acceptable for launch per NSTS-08303 and CR S041254C.

Anomaly 002 documented ice/frost accumulations along the aft edges of LH2 tank cable tray PAL ramps and pressurization line support ramps. The ice/frost accumulations were acceptable per NSTS-08303.

Anomaly 003 documented a crack with ice/frost formation at the +Y thrust strut-to-longeron interface; ice/frost formation on the adjacent longeron foam. These formations were acceptable per the NSTS-08303 criteria.

Anomaly 004 documented ice/frost formations on the +Z manhole cover closeout and aft dome +Y apex bondline. The formations were acceptable per NSTS-08303.

Anomaly 005 recorded (documentation only) typical ice and frost accumulations on the ET/ORB LH2 and LO2 umbilicals.

Anomaly 006 (documentation only) recorded ice/frost formations in the LO2 feedline bellows and support brackets. The ice and frost formations were acceptable per NSTS-08303.

Anomaly 007 documented a 4-inch crack with ice/frost formation along the aft edge of the +Y vertical strut cable tray TPS-to-ET acreage interface. The formation was acceptable per NSTS-08303.

Anomaly 008 documented ice/frost accumulations on the LH2 tank-to-intertank flange closeout bondline and in stringer root areas. The accumulations were acceptable per NSTS-08303.

Anomaly 009 documented a 4-inch crack on the aft side of the -Y vertical strut cable tray TPS surface. The crack, which is believed to be a continuation of the crack on the forward surface, was not filled with ice or frost. An observed offset was caused by structural deflection and was not the result of TPS debonding. The condition was acceptable per the NSTS-08303 criteria.

4.5 FACILITY

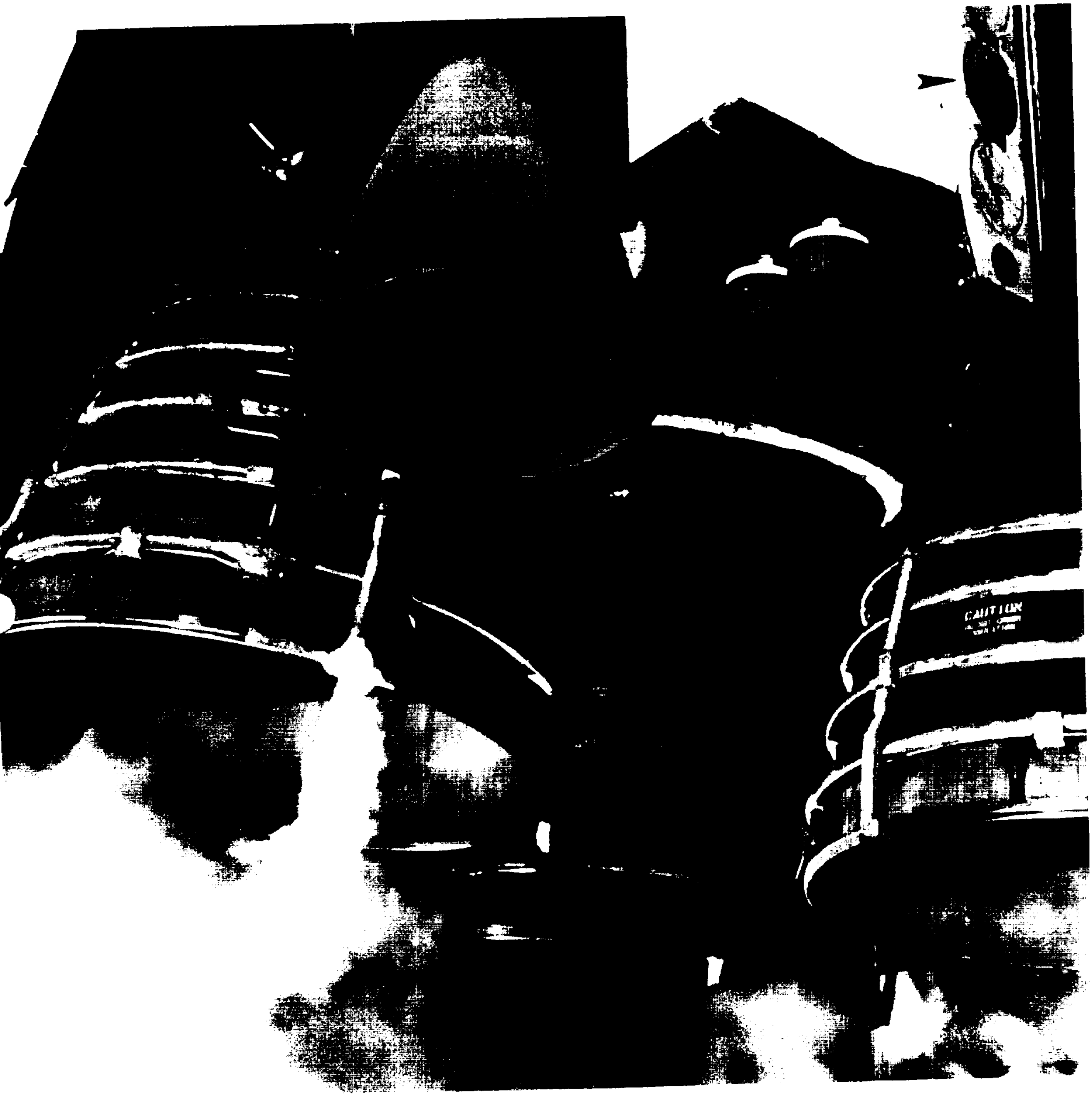
All SRB sound suppression water troughs were filled and properly configured for launch. There was no debris on the MLP deck or in the SRB holddown post areas.

No leaks were observed on either the LO2 or LH2 Orbiter T-0 umbilicals. Typical amounts of ice and frost had formed on the cryogenic lines and purge shrouds.

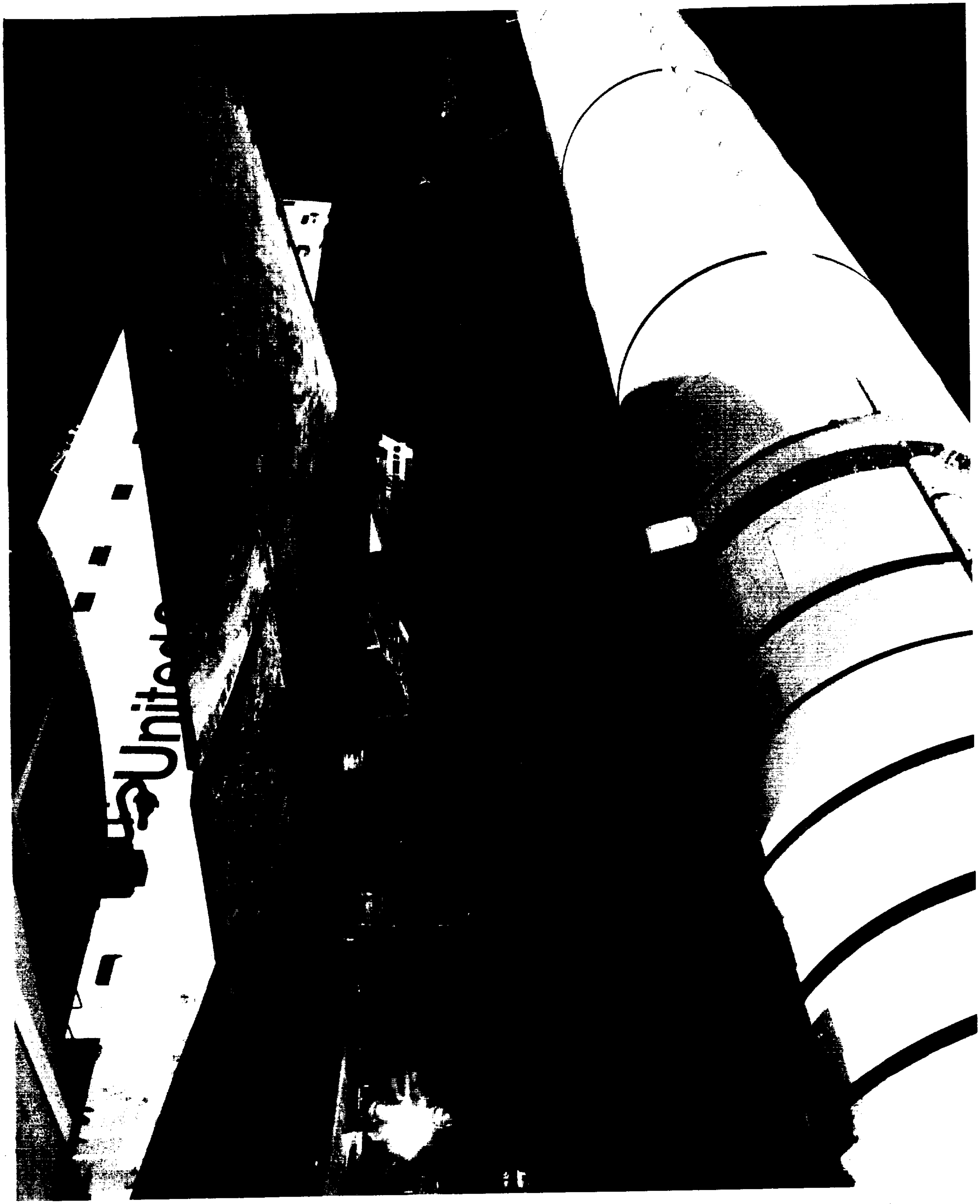
There was no apparent hydrogen leakage at the GUCP. Some ice and frost, which was expected, had accumulated on the GUCP legs and on the uninsulated parts of the umbilical carrier plate.

Venting vapors and an ice/frost buildup at the GH2 vent line 90 degree elbow/flex line flange (covered by an ice shroud) indicated the possible presence of a hydrogen leak. The possibility was confirmed by use of a hydrogen detection meter, which gave readings of at least 4 percent concentration. Since the leaking hydrogen was not driven by a pressurized GH2 vent line, and the line itself would be purged at T-90 seconds, the condition was not considered a constraint to launch. The ice buildup measured 10" x 4" x 3/8" thick and may have been a debris threat to Orbiter tiles. However, the easterly winds and the structurally enclosed area of the ice buildup would prevent large pieces of ice from falling toward the vehicle.

Visual and infrared observations of the GOX seals confirmed no leakage. No ET nosecone/footprint damage was visible after the GOX vent hood was retracted. Small icicles less than 1/2 inch in length had formed on both GOX vent ducts, but had melted prior to the time of launch.



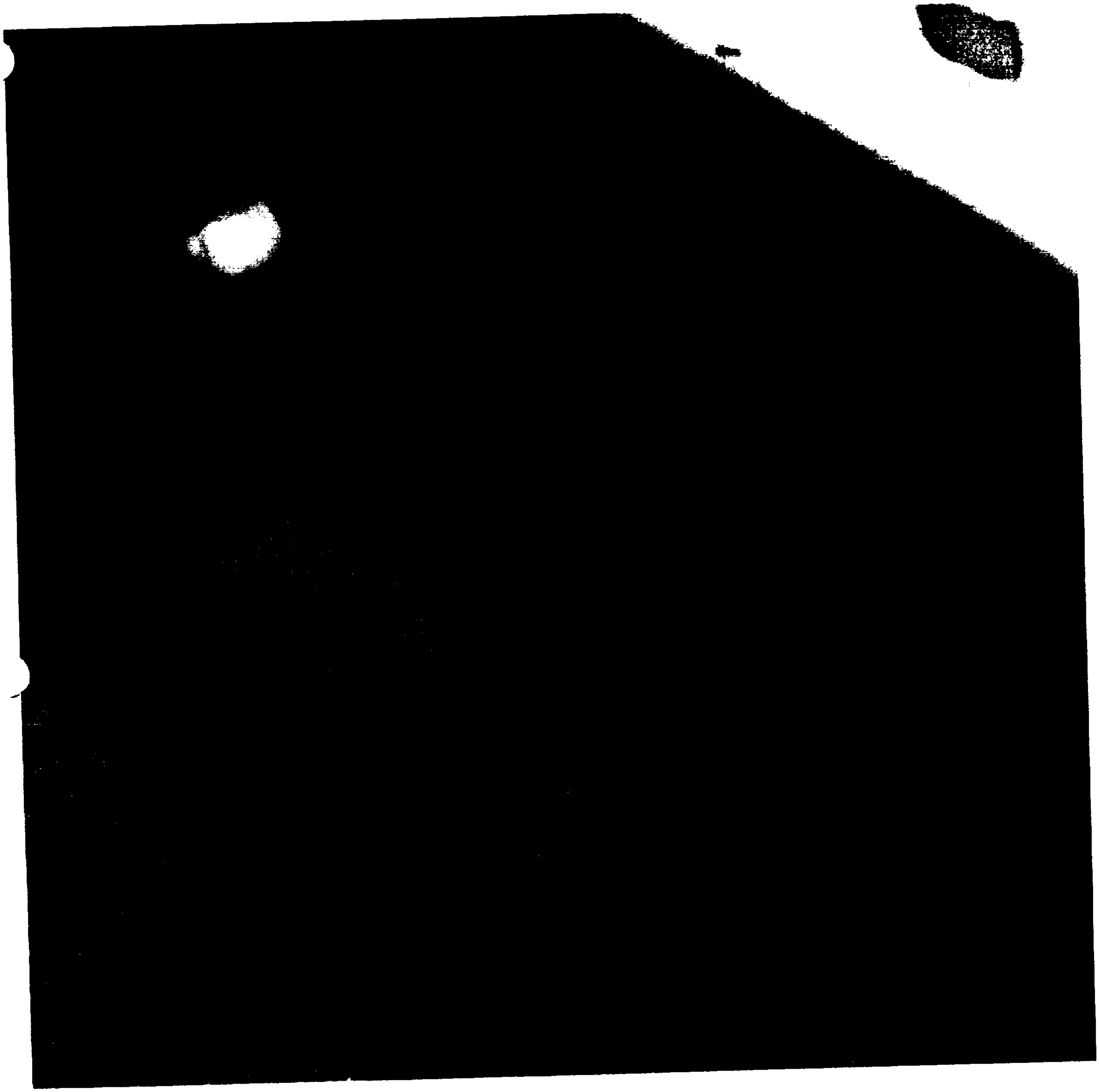
Typical ice/frost accumulations were present at the SSME #1 and #2 heat shield-to-nozzle interfaces. The R3R aft RCS thruster paper cover had been wetted by vapors.



Light condensate, but no ice or frost, was present on the LO2 and LH2 tanks. There were no acreage TPS anomalies.

Typical amounts of ice/frost had formed in the LO2 feedline bellows and support brackets. Note ice/frost ball on aft edge of pressurization line support.

The 12-inch long crack in the LH (-Y) vertical strut cable tray forward surface TPS (previously observed during the first cryo load) had increased in length. The appearance of the crack was expected due to the elimination of the stress relief cut.

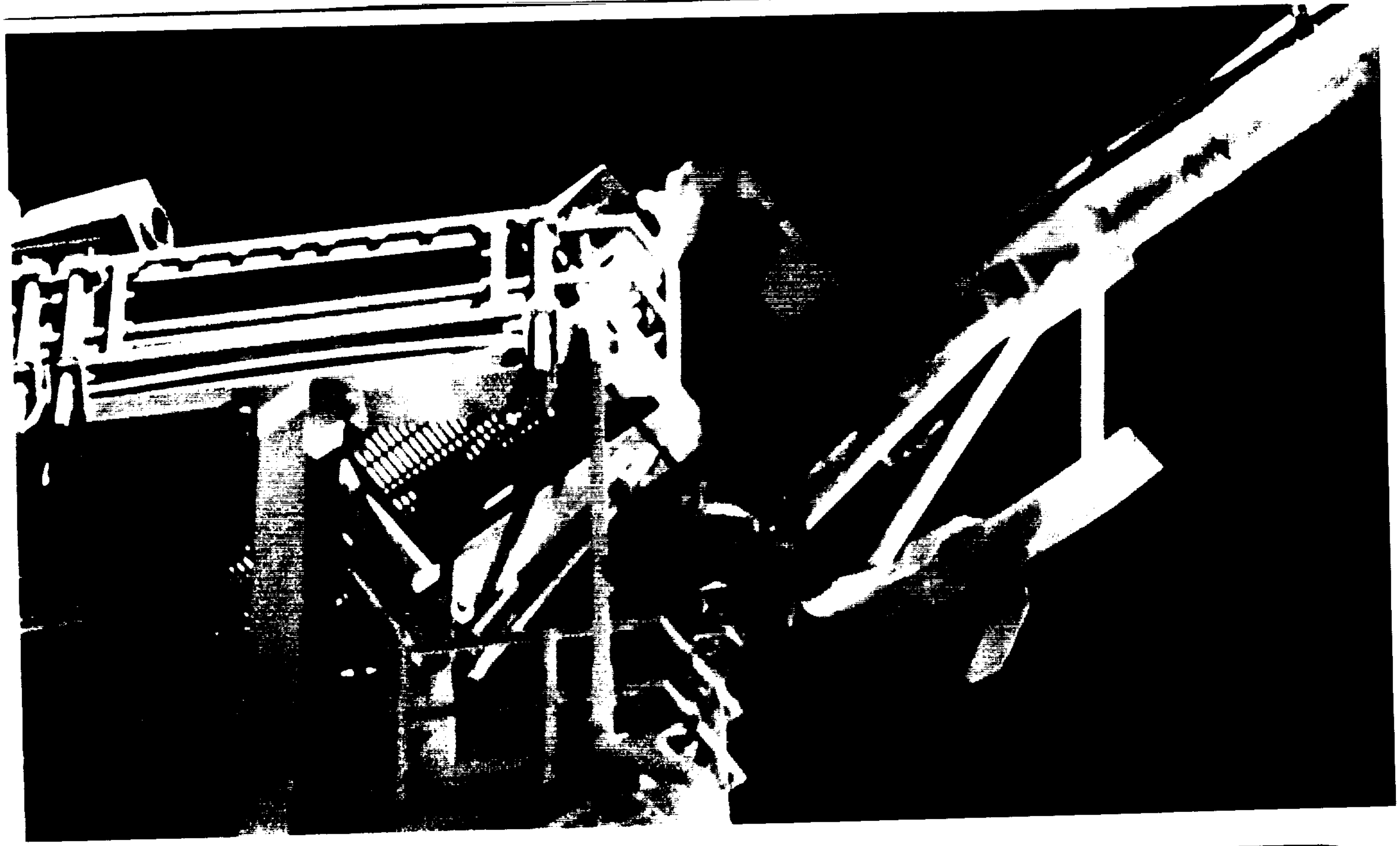


A 4-inch crack, propagating outboard from the ET interface, was most likely a continuation of the forward surface 12-inch crack along the inboard edge of the vertical strut/cable tray. The 4 inch crack exhibited some offset, which was caused by structural deflection rather than a TPS debond. Note ice formation over small TPS defect or thermal short on aft surface of strut TPS.

ORIGINAL PAGE
COLOR PHOTOGRAPH

Less than usual amounts of ice/frost had formed on the ET/ORB LH2 umbilical. No unusual vapors or cryogenic drips had appeared during tanking, stable replenish, and launch.

The 17-inch flapper valve actuator access port TPS plug was properly closed out and exhibited no blowing purge gas leaks or ice/frost formations.



A hydrogen leak at the GH2 vent line elbow/flex line flange was detected by the on-pad Ice Team. The visual signs of venting vapors and ice/frost buildup showed the exit point from the ice shroud. The line was depressurized and purged prior to launch.

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COLOR PHOTOGRAPH

5.0 POST LAUNCH PAD DEBRIS INSPECTION

The post launch inspection of the MLP, FSS and RSS was conducted on 8 April 1993 from Launch + 5 to 6-1/2 hours.

A plunger, spring, and associated hardware from the Debris Containment System (DCS) was found on holddown post #5 still attached to the stud. This hardware is normally contained in the DCS housing and remains with the SRB aft skirt during flight. No TPS materials or other flight hardware were found.

SRB holddown post (HDP) erosion was less than usual. All south HDP shoe shim material was intact, but slightly debonded at the sidewalls of HDP #1 and #2. In addition, three small pieces of material were missing from the HDP #5 inboard sidewall shim. There was no visual indication of a stud hang-up on any of the south holddown posts. There were no ordnance fragments found in the south holddown post stud holes. All of the north HDP doghouse blast covers were in the closed position and exhibited typical erosion. The SRB aft skirt purge lines were in place, but slightly damaged. The SRB T-0 umbilicals exhibited minor damage.

The GOX vent arm, OAA, and TSM's showed only minor damage. The GH2 vent line appeared to have retracted nominally. The line was latched on the eighth tooth of the latching mechanism and had no loose cables (static retract lanyard). The GH2 vent line showed typical signs of SRB plume impingement. The ET inter-tank access structure also sustained typical plume heating effects.

Post launch inspection of the GH2 vent line 90 degree elbow/flex line and flange ice shroud, where the hydrogen leak occurred during cryogenic stable replenish, revealed to visual anomalies. Disassembly of the flange revealed the old Flurorgreen gasket, which was cracked, had not been removed prior to installation of the new Fluorogold gasket. In addition, the flange bolts had not been re-torqued after the last cryogenic loading cycle.

Damage to the facility included:

1. Three loose or detached cable tray covers on the RSS 207 foot level.

2. Loose FSS 235 foot sign on the west wall of the elevator structure.

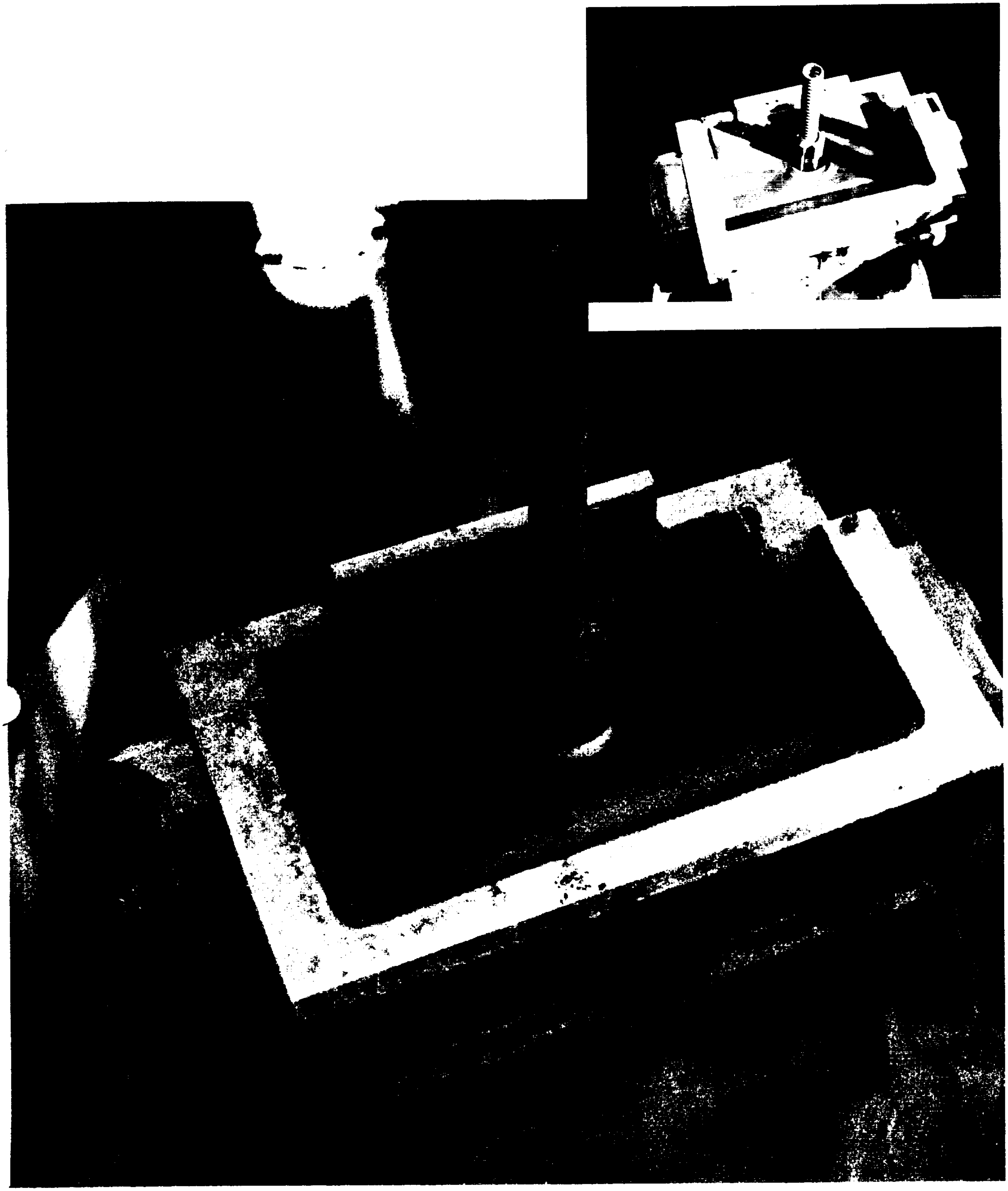
All seven emergency egress slidewire baskets were secured on the FSS 195 foot level and sustained no launch damage.

An inspection of the beach from UCS-10 to Titan complex 40, the beach road, the railroad tracks, the water areas around the pad and under the flight path was completed. No flight hardware was found.

MLP-1 was configured with overpressure sensors at the top of both TSM's, at the bottom of both SRB exhaust holes, and at the bottom of the SSME exhaust hole. All sensor readings were consistent with previous launches and within nominal limits.

Patrick AFB and MILA radars were configured in a mode for increased sensitivity for the purpose of observing any debris falling from the vehicle during ascent but after SRB separation (due to the masking effect of the SRB exhaust plume). Most of the signal registrations were very weak and often barely detectable, which generally compares with the types of particles detected on previous Shuttle flights. A total of 47 particles were imaged in the T+140 to T+311 second time period. Twelve of the particles were imaged by only one radar, 21 particles were imaged by two radars, and 14 particles were imaged by all three radars. Though the signal strength of the detected particles was comparable to previous missions, the number of detected particles was distinctly lower than that of previous Shuttle missions.

Post launch pad inspection anomalies are listed in Section 10.



A plunger, spring, and associated hardware from the Debris Containment System (DCS) was found on holddown post #5 still attached to the stud. This hardware is normally contained in the DCS housing and remains with the SRB aft skirt for flight.

6.0 FILM REVIEW AND PROBLEM REPORTS

Post Launch Anomalies observed in the Film Review were presented to the Mission Management Team, Shuttle Managers, and vehicle systems engineers. These anomalies are listed in Section 10.

Due to the Debris Containment System (DCS) plunger anomaly, retrieval of the camera film that views Holddown Post #5 had been expedited. Examination of the camera revealed the film had jammed just after camera start and no film data was recovered. A total of four launch cameras experienced hardware malfunctions or film breaks.

6.1 LAUNCH FILM AND VIDEO SUMMARY

A total of 101 film and video data items, which included forty videos, thirty-six 16mm films, twenty-one 35mm films, and four 70mm films, were reviewed starting on launch day.

No major vehicle damage or lost flight hardware was observed that would have affected the mission.

During SSME startup, free burning hydrogen drifted under the body flap. SSME ignition, Mach diamond formation, and gimbal profile appeared normal (RSS STI, C/S-2 STI, OTV 151, 163, 170, 171). Several debris-induced flashes occurred in the plume of SSME #3 prior to liftoff (E-2, 3, 5, 19).

SSME ignition vibration/acoustics caused the loss of tile surface coating material from four places on the base heat shield (E-17, 20) and one place on the body flap near SSME #3 (E-19).

A thin, rectangular, dark object (possibly a tile gap filler or GSE tile shim/spacer) originated from the LH aft RCS stinger tiles (edge of the aft surface) on film items E-20, 77.

Fore-and-aft movement of the Orbiter base heat shield in the centerline area between the SSME cluster occurred during engine startup. The motion was similar to that observed on previous launches (E-76, 77).

SSME ignition caused ice/frost to fall from the ET/Orbiter umbilicals. Several pieces of ice appeared to contact lower surface tiles near the umbilical cavity sill. Ice from the top side of the LH2 ET/ORB umbilical bounced off of the cable tray and contacted Orbiter lower surface tiles. No damage was visible in both cases. There were no unusual vapors or cryogenic drips from the ET/ORB umbilicals during tanking, stable replenish, ignition, liftoff, or tower clear (OTV 109, 150, 154, 163, 164, E-5, 6, 25).

The tumble valve cover was intact. Light frost was present in the ET GOX vent louvers. There was no TPS damage to the ET nose cone acreage, footprint, or fairing. (OTV 113, 160, 161, 162). ET "twang" was typical (E-79).

The Orbiter LH2 and LO2 T-0 umbilicals disconnected and retracted properly (OTV 149, 150, 163). Separation of the GUCP from the ET was nominal. The GH2 vent line retracted and latched normally with no rebound (OTV 104, E-33). No unexpected slack in the static retract lanyard was present during retraction. More vapors than usual emanated from the vent line disconnect after separation. Lack of lighting at the vent line hinge area prevented observation of the hydrogen leak and ice formation at the line elbow/flex line flange (E-41, 42, 48, 50).

No film data of the HDP #5 DCS plunger anomaly was obtained due to the E-12 film breakage. No other MLP or FSS films viewed the HDP #5 area. However, several films viewing the Orbiter lower surface showed no unidentified debris objects moving toward the Orbiter from the LH SRB aft skirt area and no obvious tile damage from debris impacts.

No stud hang-ups occurred on any of the holddown posts. No debris was visible falling from any of the aft skirt HDP DCS/stud holes. Film E-9, frame 4016, showed a thin, rectangular, silver colored object (possibly a piece of duct tape) drawn toward the SSME exhaust hole by aspiration.

Film item E-60 confirmed that water flowed properly from all MLP rainbirds.

Several pieces of ice from the LO2 feedline upper bellows fell aft, but did not appear to contact Orbiter tiles (OTV 161, 166, E-5, 6, 34, 40).

Two debris objects appeared over the SSME flame trench south of the vehicle after liftoff: 1) dark piece (E-63, frame 975) may be a piece of SRB throat plug material; 2) square, metallic object (E-63, frame 1191) may be a facility cable tray cover. Numerous debris objects (pieces of SRB throat plug) appeared over the SRB flame trench north of the vehicle after SRB ignition (OTV 133, TV-4B, TV-7, E-62, 222).

White flashes occurred in the SSME plume during and after the roll maneuver (OTV 141, ET-207, E-52, 54, 57, 207, 212, 218). A large, orange flash, typically induced by debris, occurred in the SSME plume during ascent (E-205, frame 1298; E-223, frames 2857 and 4432).

Pieces of the ET/ORB umbilical purge barriers (baggies) fell aft following the roll maneuver and were caught in the plume recirculation (E-52, 220, 223).

Clusters of particles falling aft of the Orbiter after completion of the roll maneuver were traced to the forward RCS thrusters and were pieces of RCS paper covers (E-212, 220, 222).

A light colored particle appeared below the right wing near the middle of the inboard elevon at GMT 49:05:29:18.612 and may have been a paper cover from the forward RCS thrusters (E-59, 213). The light colored object was also visible in E-57, 05:29:18.611 GMT; E-224, 05:29:17.563; and E-223, frame 1920.

A light colored object first appeared forward of the RH wing at 05:29:45.349 GMT and fell aft of the vehicle. The object may have been a piece of SRB propellant dropping out of the SRB plume and appeared in this location due to the angle of view by the ground camera (E-224).

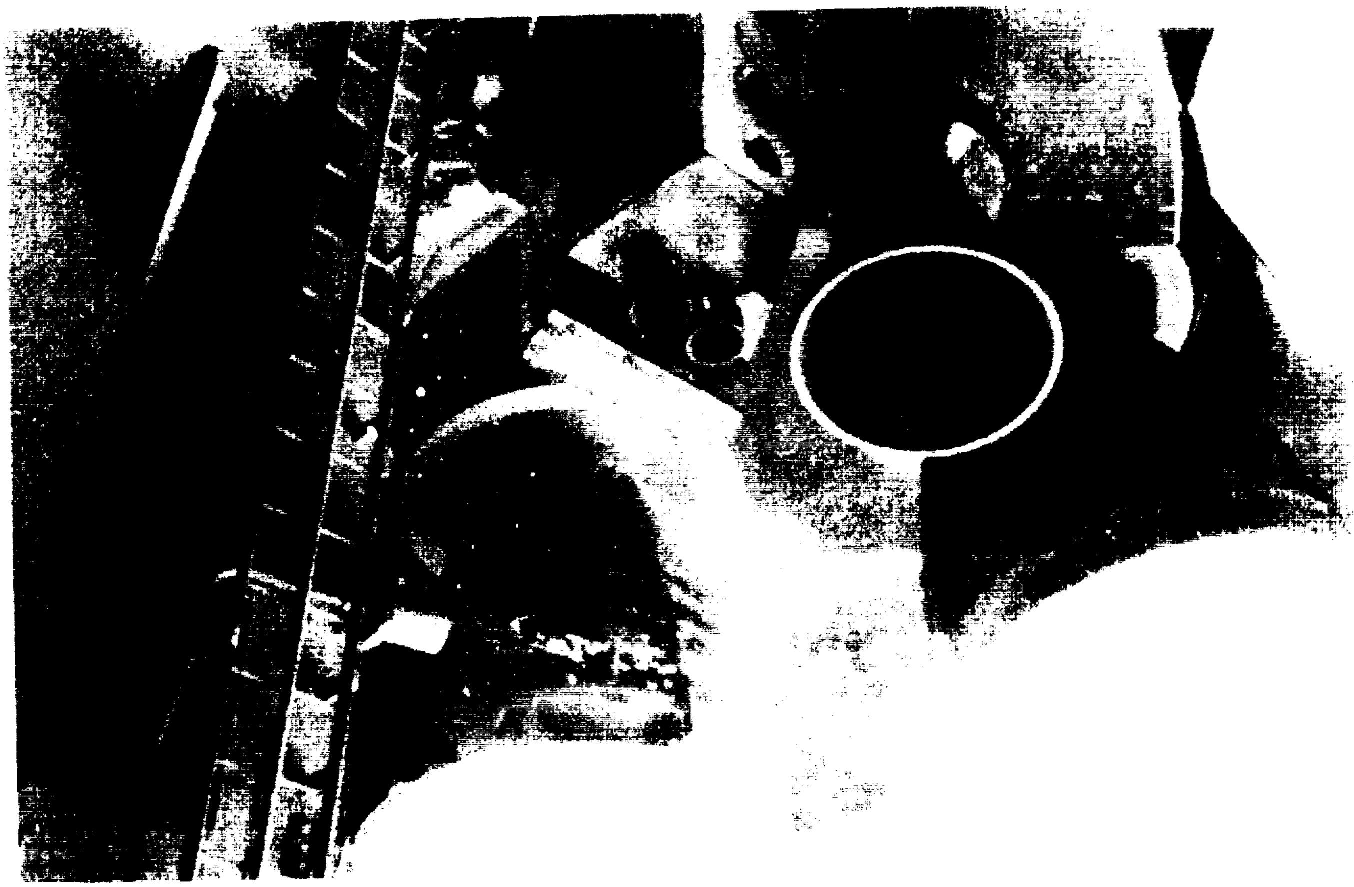
Numerous small particles, most likely pieces of SRB propellant, dropped out of the SRB plumes almost continuously during ascent (TV-5, TV-21B, ET-207, E-52, 57, 59, 207, 208, 220, 224).

There were numerous views of the loose thermal curtain tape under the RH SRB aft skirt near the HDP #4 foot (E-57, 60, 62). Film item 223 showed two pieces of the thermal curtain tape falling aft at frames 3786 and 4655.

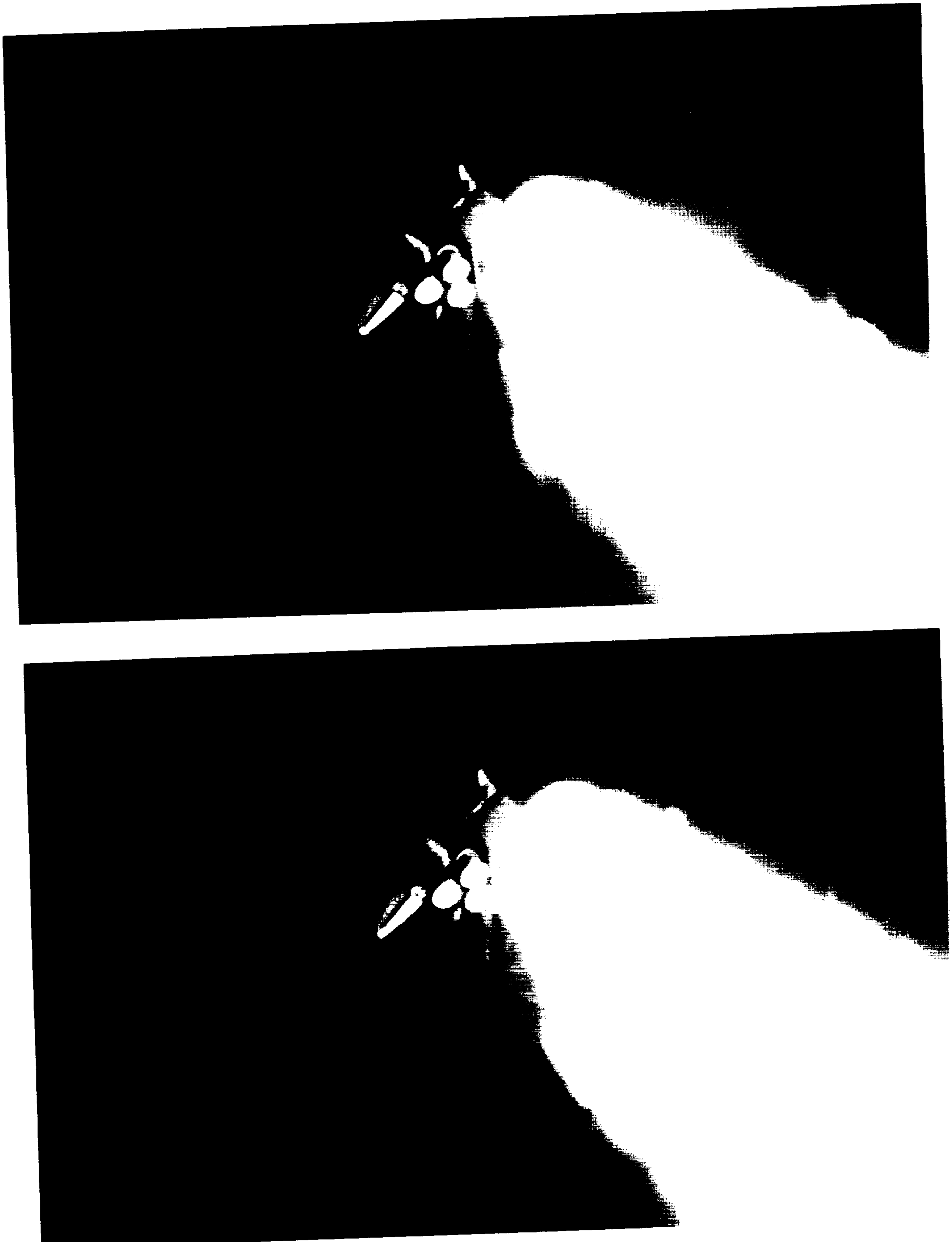
Movement of the body flap was similar to previous flights (E-207, 212).

Exhaust plume recirculation appeared typical. SRB plume tailoff and separation appeared normal. Numerous pieces of slag fell out of the SRB plume before, during, and after SRB separation from the ET (TV-13, ET-207, ET-208, ET-212, E-207, 208, 212).

SRB parachute cameras E-301 and 302 were not run due to dark conditions.



A thin, rectangular object, most likely a tile gap filler or GSE shim/spacer, originated from the left aft RCS stinger tiles (edge of the aft surface) fell during SSME ignition.



A large, orange flash, typically induced by debris, occurred in the SSME plume during ascent

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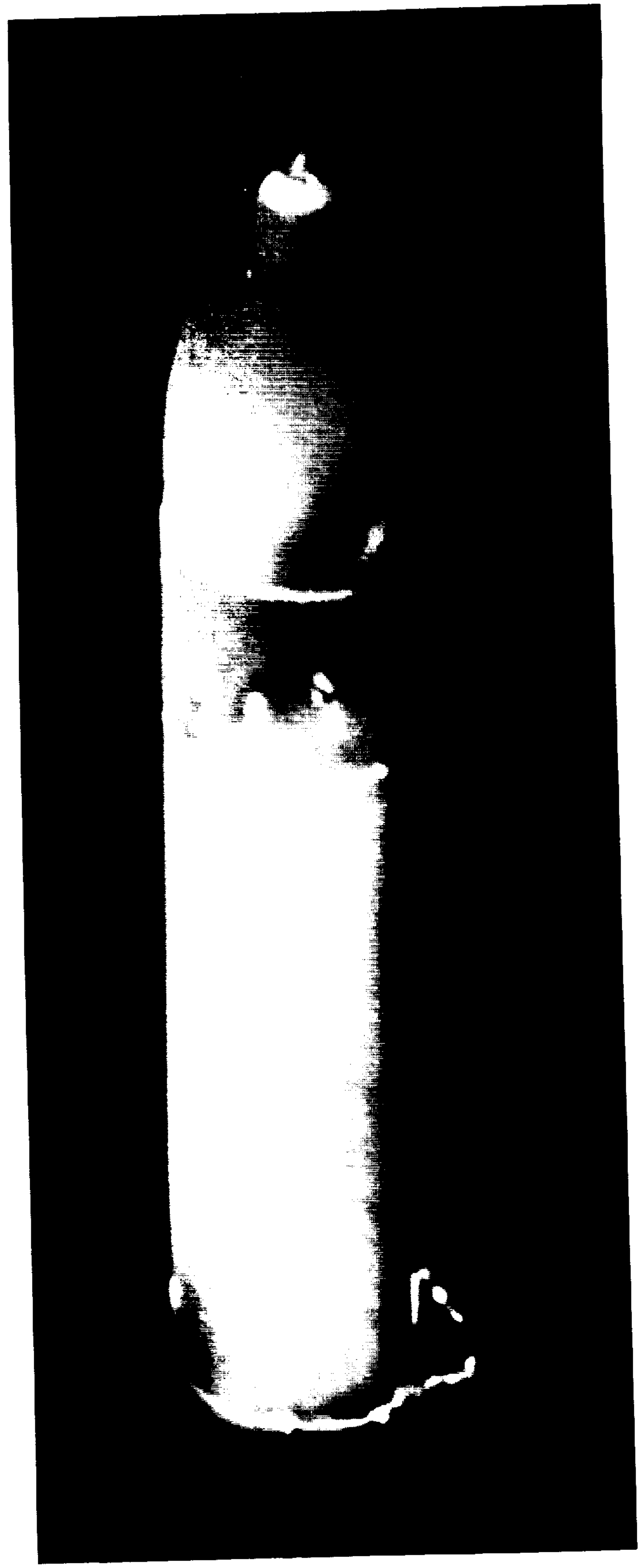
6.2 ON-ORBIT FILM AND VIDEO SUMMARY

DTO-0312 was performed by the flight crew and seventy 35mm still images were obtained of the External Tank (-Z side) after separation from the Orbiter. OV-103 was not equipped to carry umbilical cameras.

ET separation from the Orbiter appeared nominal. No structural damage was visible. The BSM burn scars on the LO2 tank were typical. No anomalies were observed on the nosecone, LO2 tank acreage, LH2 tank acreage, aft hard point, and aft dome acreage.

As many as 12 divots were present in the LH2 tank-to-intertank flange closeout on the ET -Z side. Some of the divots were 10-12 inches in diameter.

As many as 11 divots were also visible in the intertank acreage on the -Z side of the ET. Numerous divots appeared in a line and may be indicative of a spray or processing problem. Depth could not be determined due to the absence of shadows or stringers being visible in the divots. Several of the divots were estimated to be 24 inches in diameter. An IFA was taken against the new block of intertanks, which have shown an increasing trend in the appearance of acreage divots.



Eleven divots were visible in the intertank acreage on the ET -Z side. Numerous divots appeared in a line and may be indicative of a spray or processing problem. Depth could not be determined, but several of the divots were estimated to be 24 inches in diameter. Twelve divots, some of which were 10-12 inches in diameter, occurred in the -Z LH2 tank-to-intertank flange closeout.

6.3 LANDING FILM AND VIDEO SUMMARY

A total of 27 landing films and videos, which included six 16mm high speed films, nine 35mm large format films, and twelve videos, were reviewed.

Orbiter performance in the Heading Alignment Circle (HAC) and on final approach appeared nominal. The landing gear extended properly. Infrared views of the Orbiter on final approach showed as many as six Ames gap fillers falling from the nose landing gear area when the doors were opened. The gap fillers had been inserted into gaps after the nose gear doors were closed to prevent re-entry heat intrusion. The appearance of the gap fillers is an expected occurrence.

The Orbiter touched down on the runway near the 1000 foot marker. Left and right main landing gear contact with the runway was almost simultaneous.

The drag chute was deployed just after breakover, but before the nose gear touched down on the runway. Operation of the drag chute appeared nominal though the parachute riser lines contacted the vertical stabilizer "stinger" and damaged three tiles. The drag chute stayed close to the Orbiter centerline and did not cause the Orbiter to yaw or deviate from the runway centerline during rollout.

Touchdown of the nose landing gear was smooth. There were no anomalies during rollout. However, damage to two tiles on the lower surface of the RH wing leading edge extension was visible.

7.0 SRB POST FLIGHT/RETRIEVAL DEBRIS ASSESSMENT

Both Solid Rocket Boosters were inspected for debris damage and debris sources at CCAFS Hangar AF on 10 April 1993 from 0830 to 1030 hours.

7.1 RH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The RH frustum was missing no TPS, but had 11 MSA-2 debonds over fasteners (Figure 7). Significant blistering of the Hypalon paint top layer had occurred in an area between the -Y and +Y axes from the BSM's to the 395 ring frame. No sooting or charring was visible in the open paint blisters and on the Hypalon basecoat. All BSM aero heatshield covers were locked in the fully opened position, although the two right cover attach rings had been bent by parachute riser entanglement.

The RH forward skirt acreage MSA-2 exhibited two debonds (3 and 1.5 inches in diameter, respectively) near the ET/SRB attach fitting. A 5" x 3" piece of MSA-2 was missing from an area near the ET/SRB attach fitting, but the substrate was not sooted. Both RSS antennae covers/phenolic base plates were intact (Figure 8). Minor blistering of the Hypalon paint occurred on the systems tunnel cover and around the ET/SRB attach point. No pins were missing from the frustum severance ring. The forward separation bolt appeared to have separated cleanly.

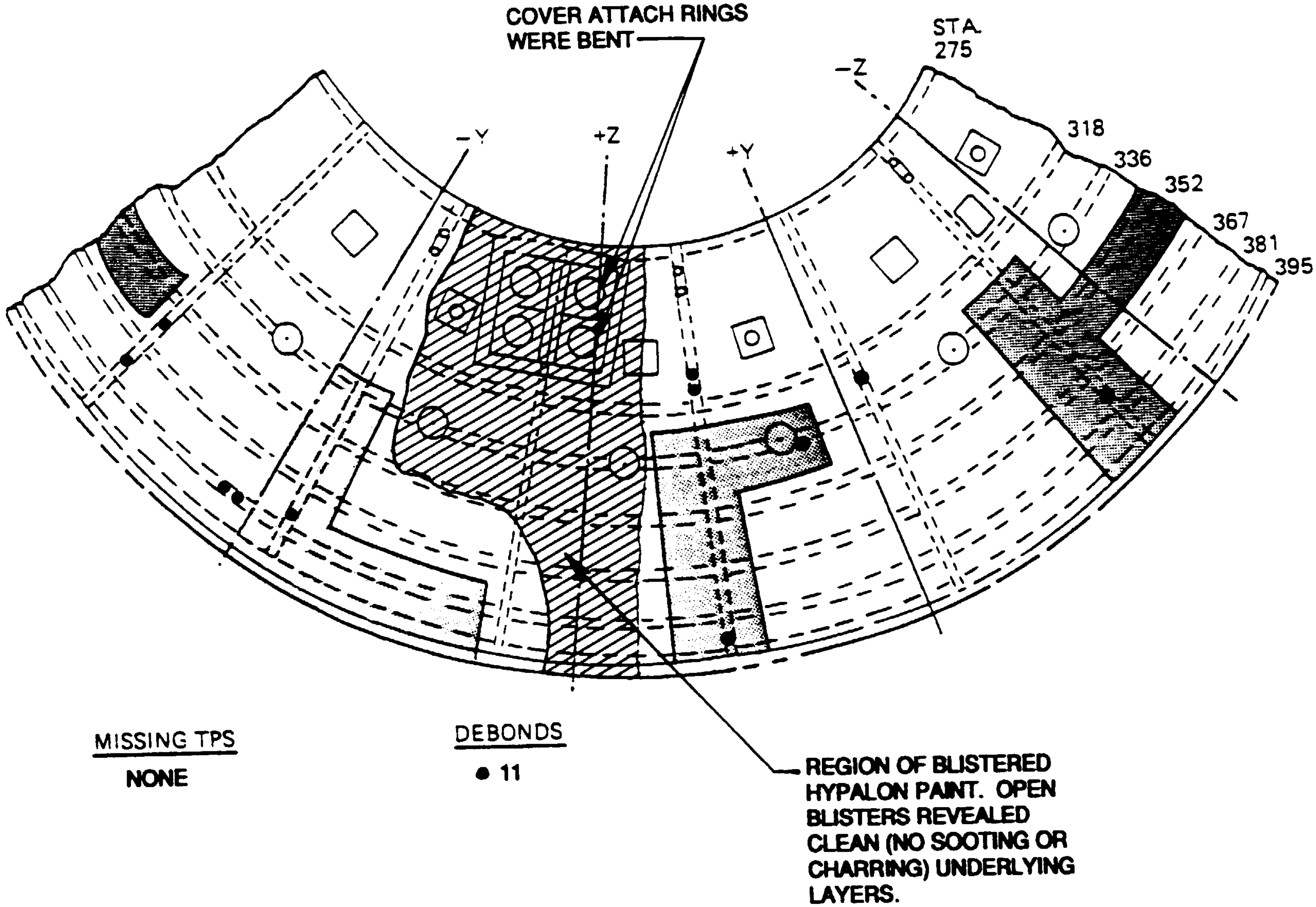
The Field Joint Protection System (FJPS) closeouts were generally in good condition. Minor trailing edge damage to the FJPS and the GEI cork runs were attributed to debris resulting from severance of the nozzle extension. White topcoat, approximately 2.5 feet in circumferential length, was blistered/missing from the aft field joint closeout.

Separation of the aft ET/SRB struts appeared normal. The ET/SRB aft struts, ETA ring, IEA, and IEA covers appeared undamaged. K5NA closeout material, 5" x 1" in size, was missing from the upper strut fairing. All three aft booster stiffener rings also appeared undamaged. The aft booster stiffener ring splice plate closeouts were intact and no K5NA material was missing.

The phenolic material on the kick ring was delaminated. The K5NA closeouts (protective domes) on the kick ring forward and aft fasteners are no longer used. RTV-133 has replaced the K5NA over the forward fasteners. The aft skirt acreage TPS was generally in good condition (Figure 9).

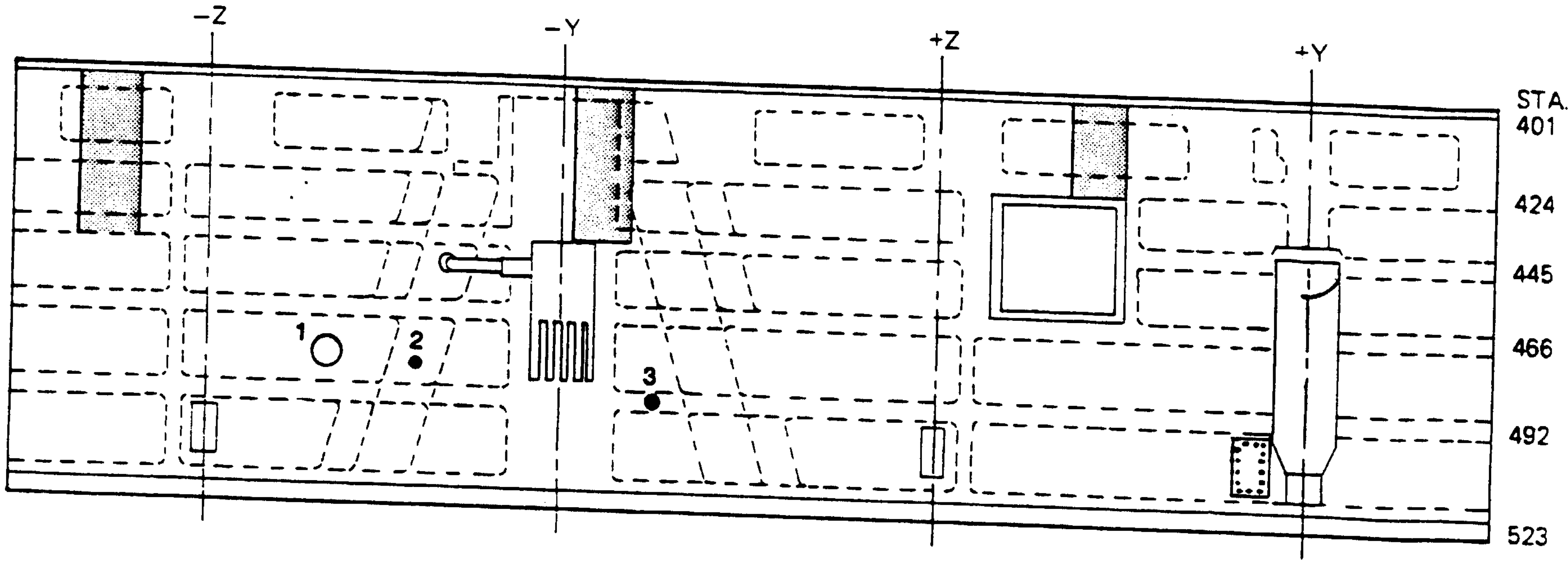
None of the aft skirt HDP EPON shim material was lost prior to splashdown. All four Debris Containment System (DCS) plungers were seated properly.

FIGURE 7. **RIGHT SRB FRUSTUM**



EGG/V-326

FIGURE 8. **RIGHT SRB FWD SKIRT**



TPS MISSING

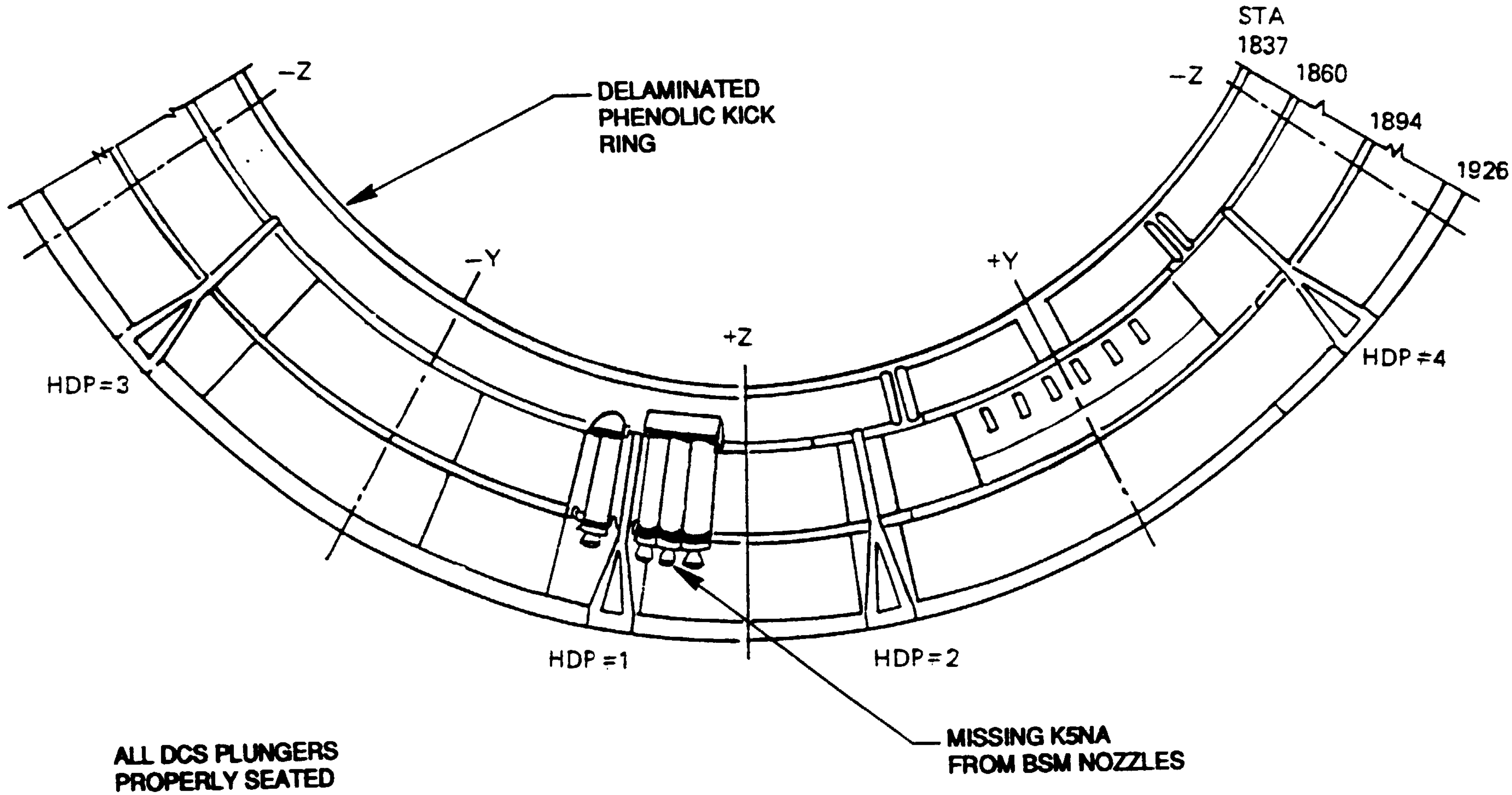
1) 5" x 3" (MAY BE HANDLING DAMAGE)

DEBONDS

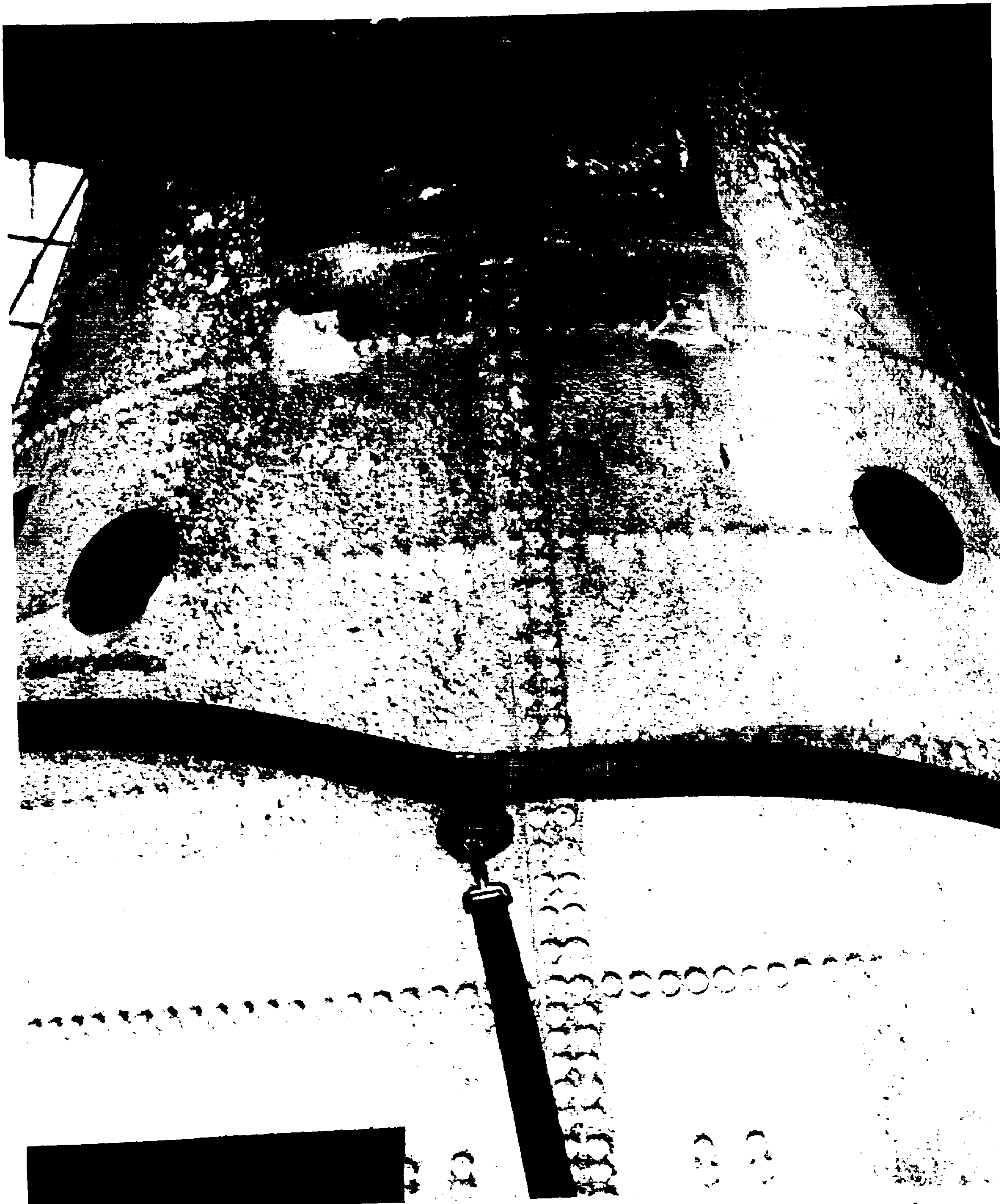
2) 1.5" DIA
3) 3.0" DIA

TYPICAL BLISTERING OF HYPALON PAINT ON ET ATTACH FITTING AND SYSTEMS TUNNEL COVER

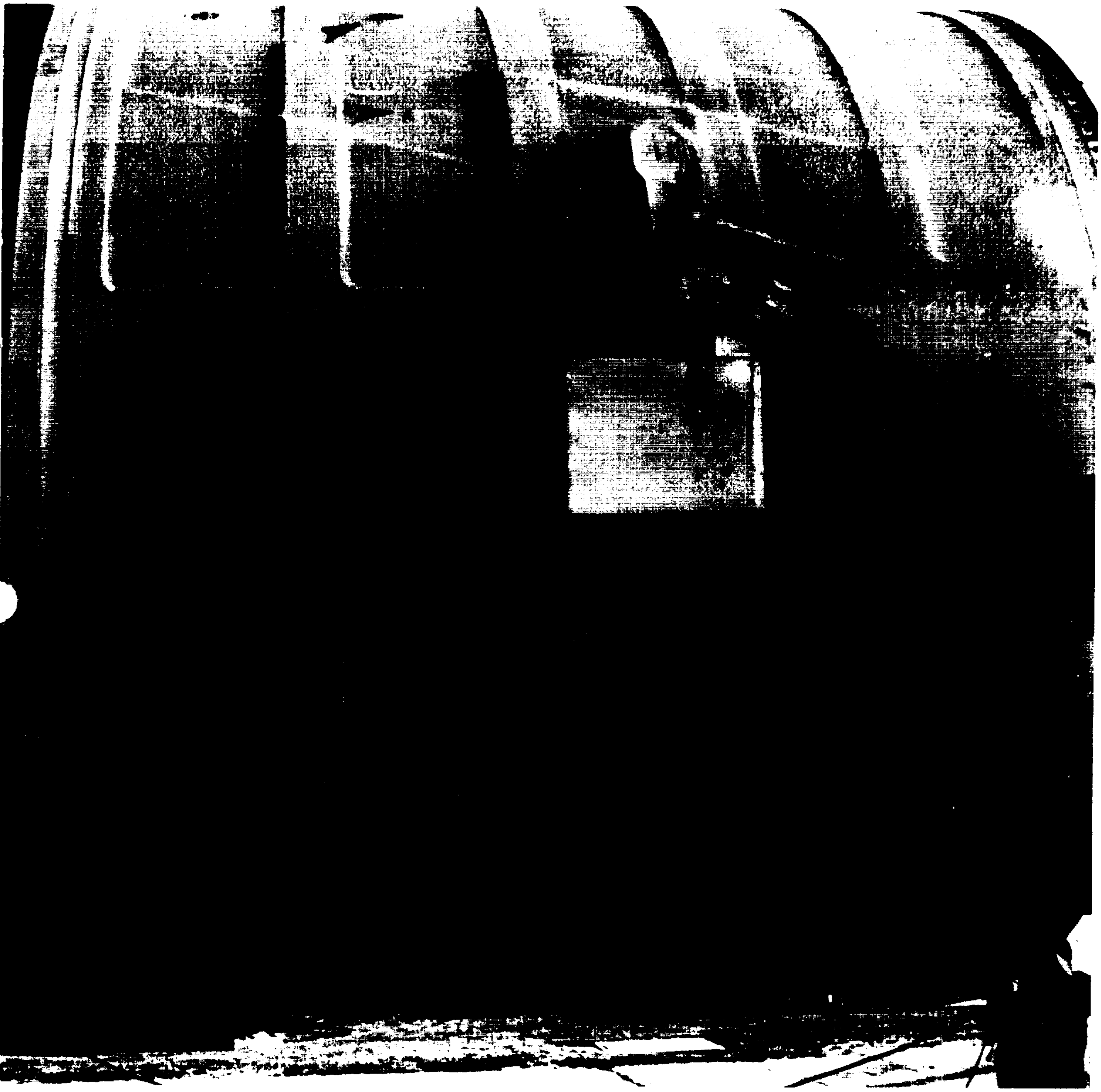
FIGURE 9. **RIGHT SRB AFT SKIRT EXTERIOR TPS**



EGG/V 326C



The RH frustum was missing no TPS, but had 11 MSA-2 debonds over fasteners. Significant blistering of the Hypalon paint top layer had occurred in an area around and aft of the BSM's.



The RH forward skirt acreage MSA-2 exhibited two debonds near the ET/SRB attach fitting. A 5"x3" piece of MSA-2 was missing, but the substrate was not sooted. Both RSS antenna covers/TPS were intact.

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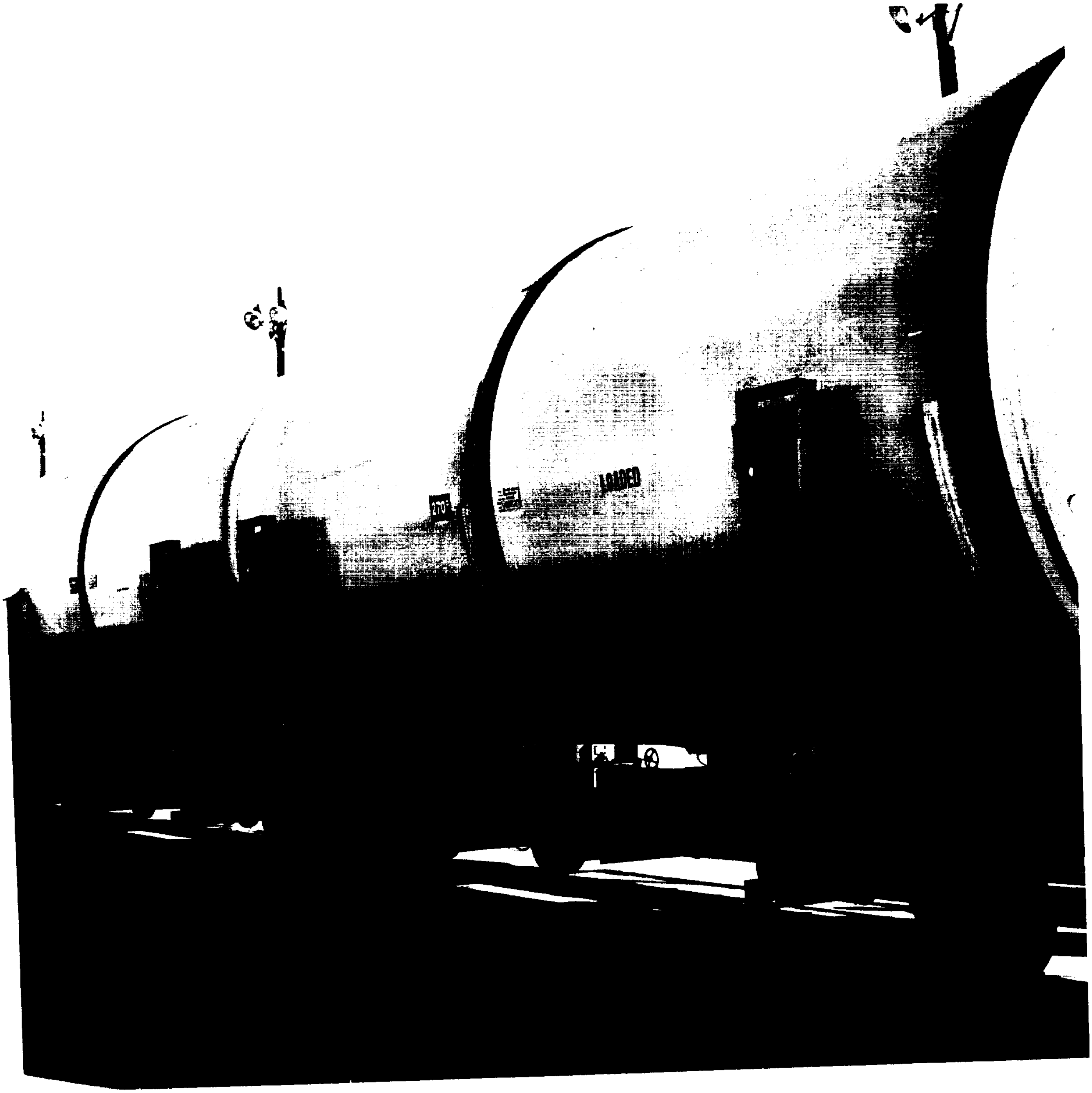

Overall view of the SRM segment cases

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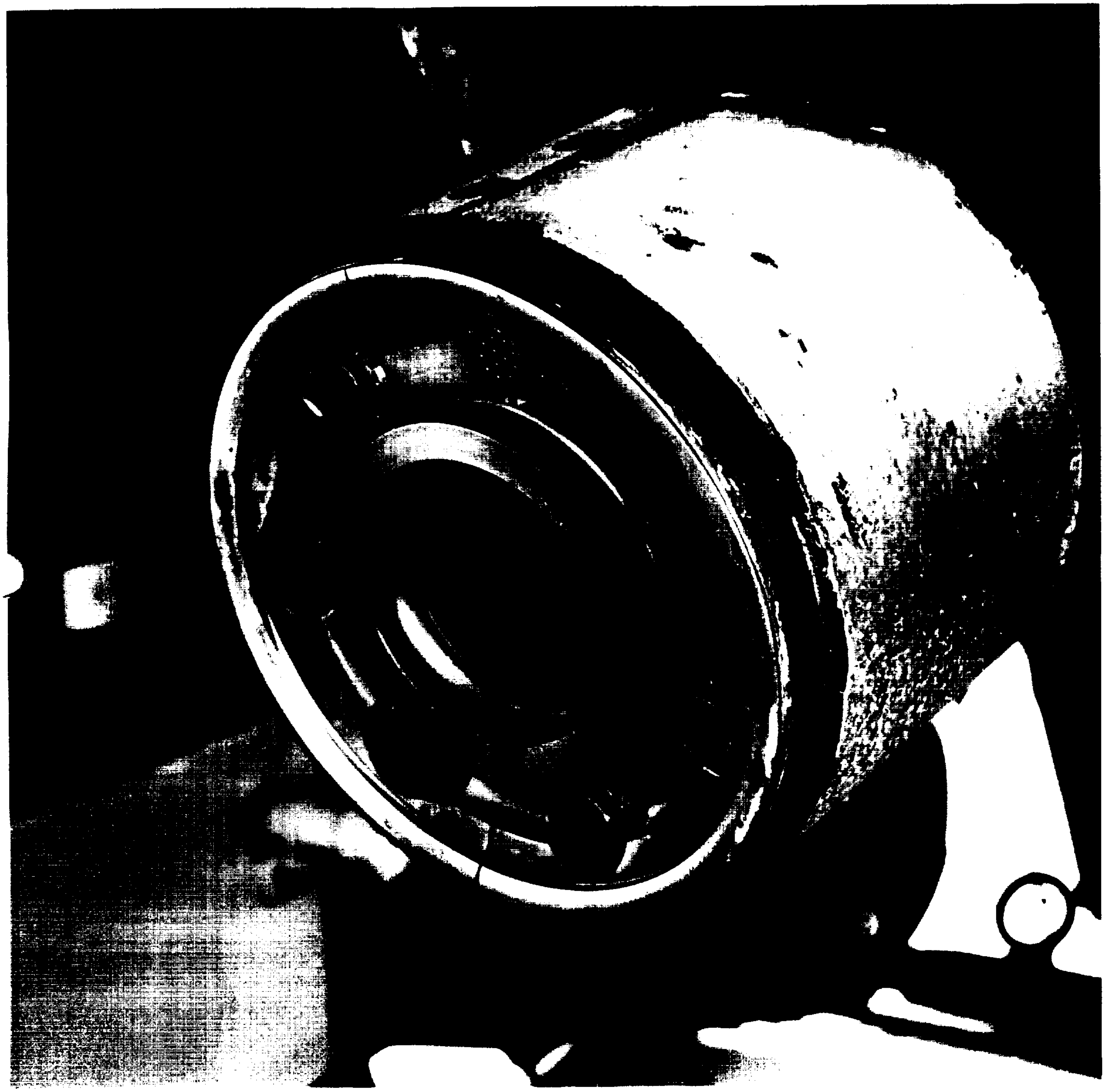


K5NA, 5"x1" in size, was missing from the upper strut fairing

7.2 LH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The LH frustum was missing no TPS, but had a total of 20 MSA-2 debonds (Figure 10). Minor localized blistering of the Hypalon paint had occurred along the 395 ring. The BSM aero heat shield covers were locked in the fully opened position.

The LH forward skirt exhibited no debonds or missing TPS. Both RSS antennae covers/phenolic base plates were intact. Minor blistering of the Hypalon paint occurred near the ET/SRB attach point and on the systems tunnel cover (Figure 11). No pins were missing from the frustum sverance ring. The forward separation bolt appeared to have separated cleanly.

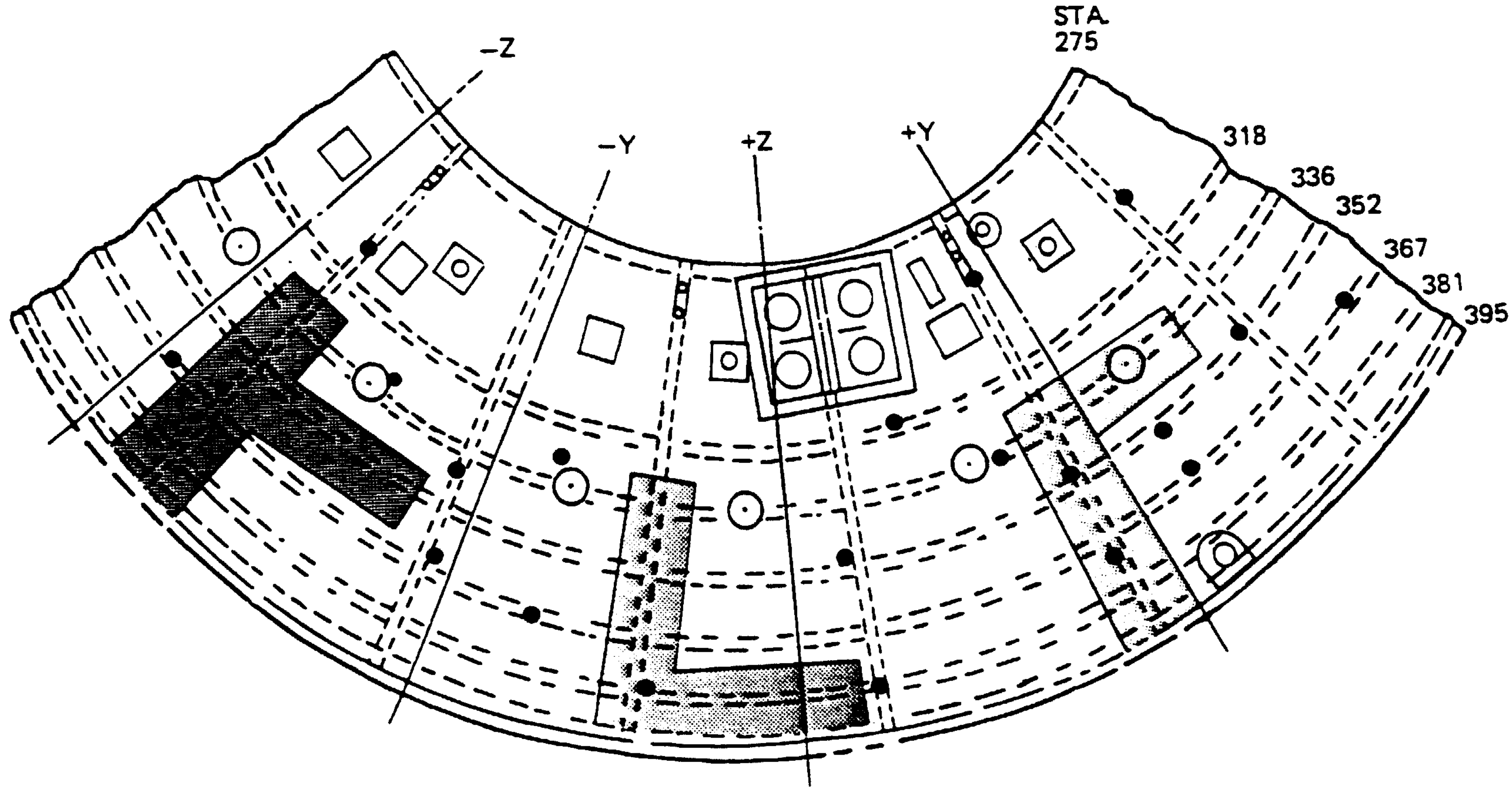
The Field Joint Protection System (FJPS) closeouts were in good condition. In general, minor trailing edge damage to the FJPS and the GEI cork runs were attributed to debris resulting from severance of the nozzle extension. The dark marks observed on the aft center segment during the launch countdown (IPR 56V-0105) were still visible and appeared to be field joint closeout grease.

Separation of the aft ET/SRB struts appeared normal. The ET/SRB aft struts, ETA ring, IEA, and IEA covers appeared undamaged. K5NA closeout material, 2" x 1.5" in size, was missing from the upper strut fairing. All three aft booster stiffener rings appeared undamaged. The stiffener ring splice plate closeouts were intact and no K5NA material was missing.

The phenolic material on the kick ring was delaminated in only localized areas. The K5NA closeouts (protective domes) on the kick ring forward and aft fasteners are no longer used. RTV-133 has replaced the K5NA over the forward fasteners. The aft skirt acreage TPS was generally in good condition (Figure 12).

Examination of the Holddown Post #5 stud hole revealed no obvious broaching or unusual abrasion due to the loss of the Debris Containment System (DCS) plunger/spring. The frangible nut halves were contained inside the DCS housing. The amount of debris lost from the DCS will be determined during the post flight disassembly. The other three DCS plungers were seated properly. None of the aft skirt HDP EPON shim material was lost prior to splashdown.

FIGURE 10. **LEFT SRB FRUSTUM**



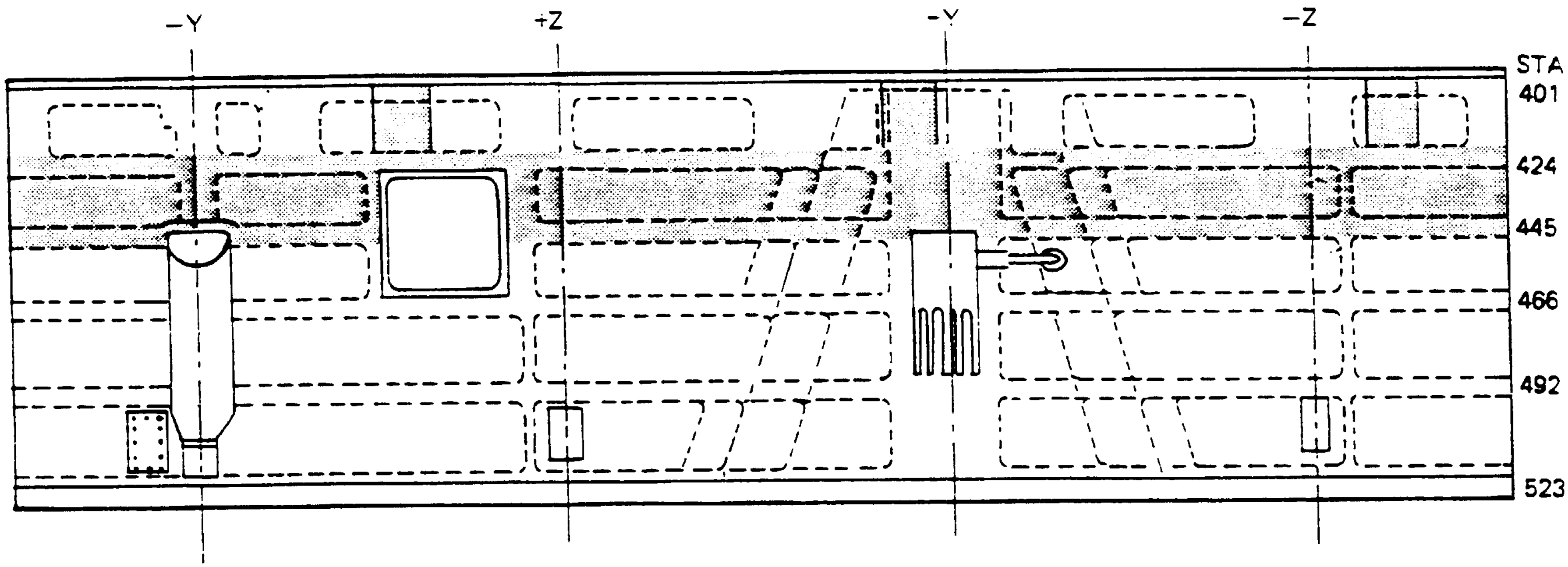
MISSING TPS

NONE

DEBONDS

● 20

FIGURE 11. **LEFT SRB FWD SKIRT**



TPS MISSING

NONE

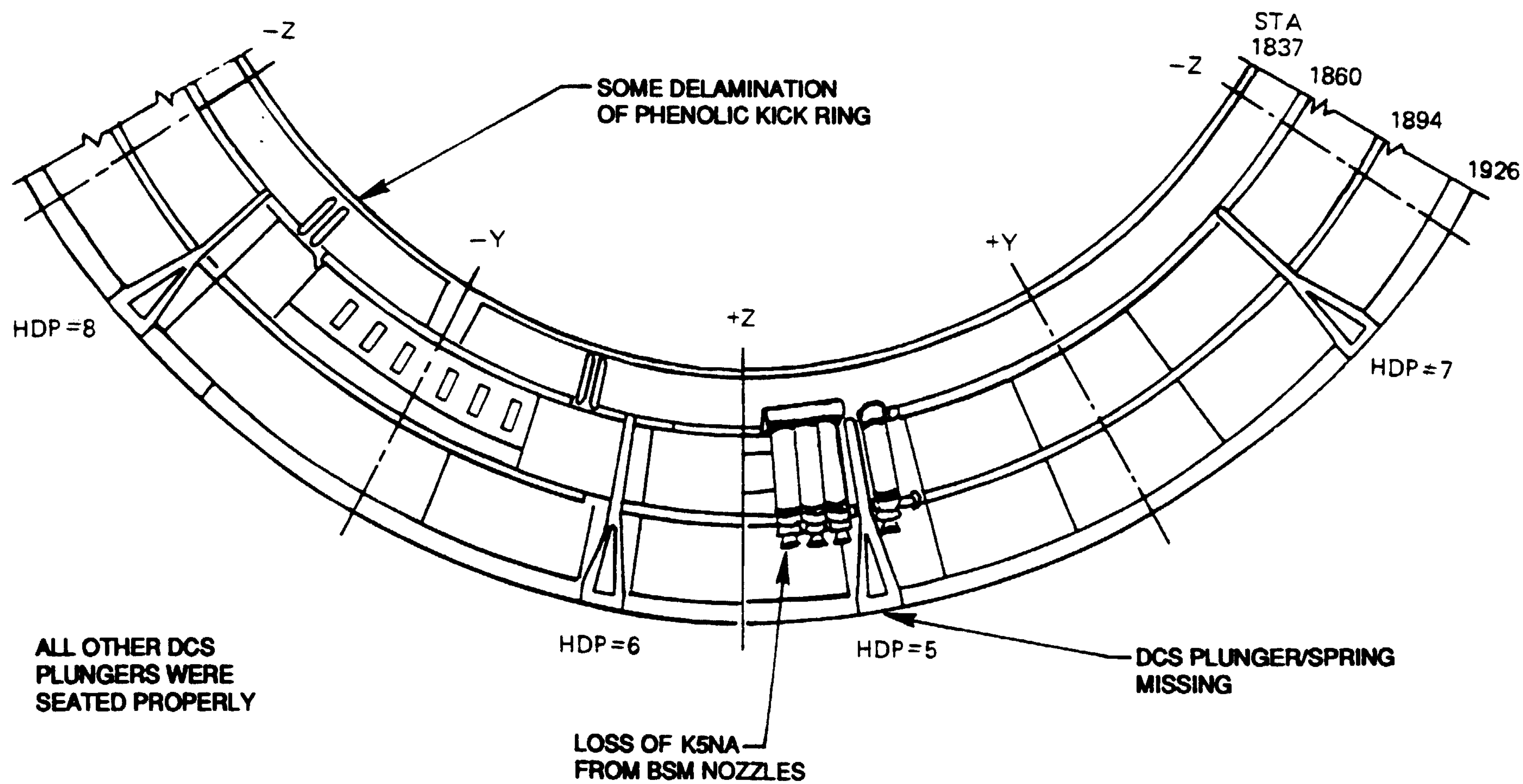
DEBONDS

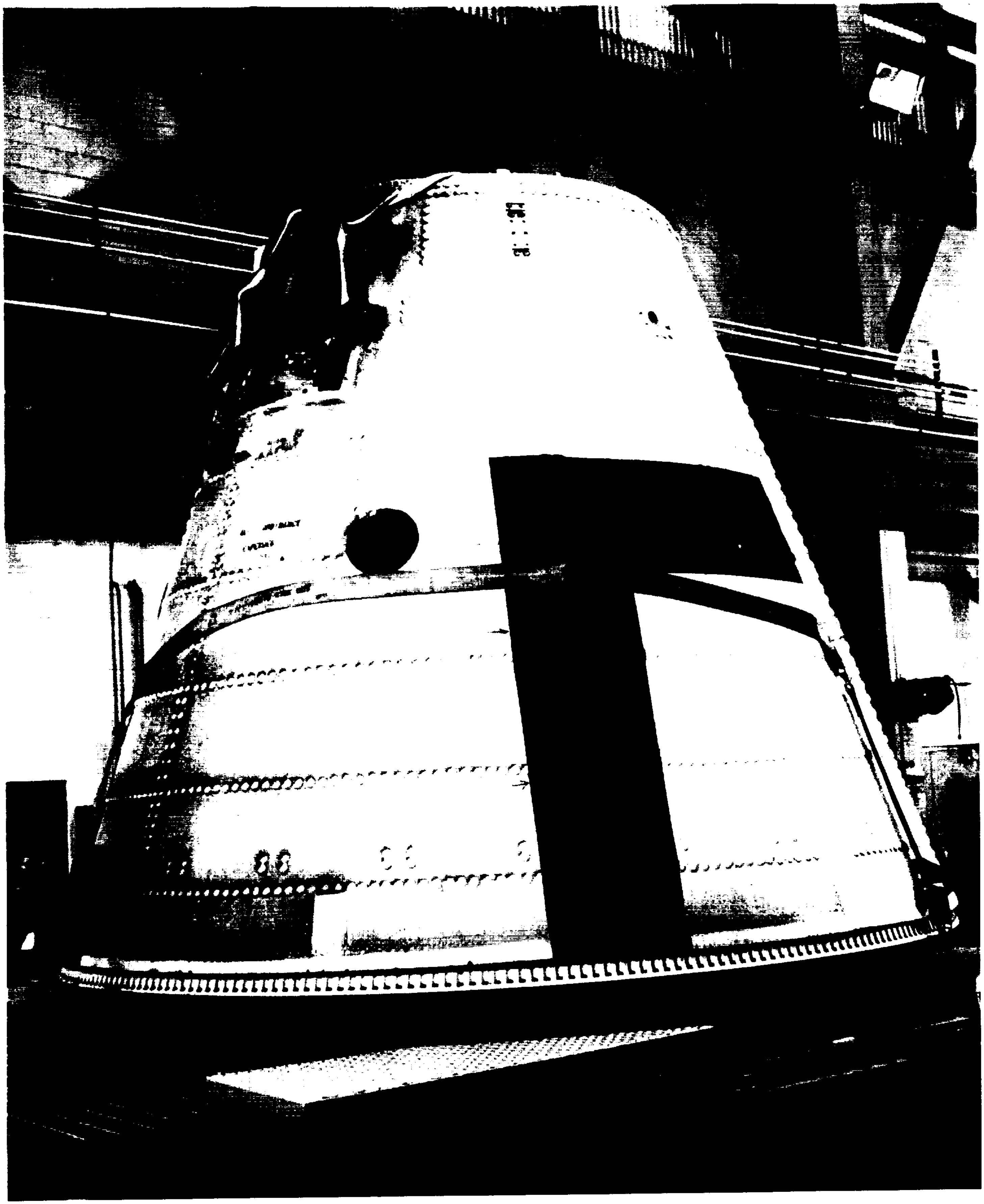
NONE

LOCALIZED BLISTERING OF HYPALON PAINT AROUND ET/SRB ATTACH FITTING AND SYSTEMS TUNNEL COVER

EGG/V-326D

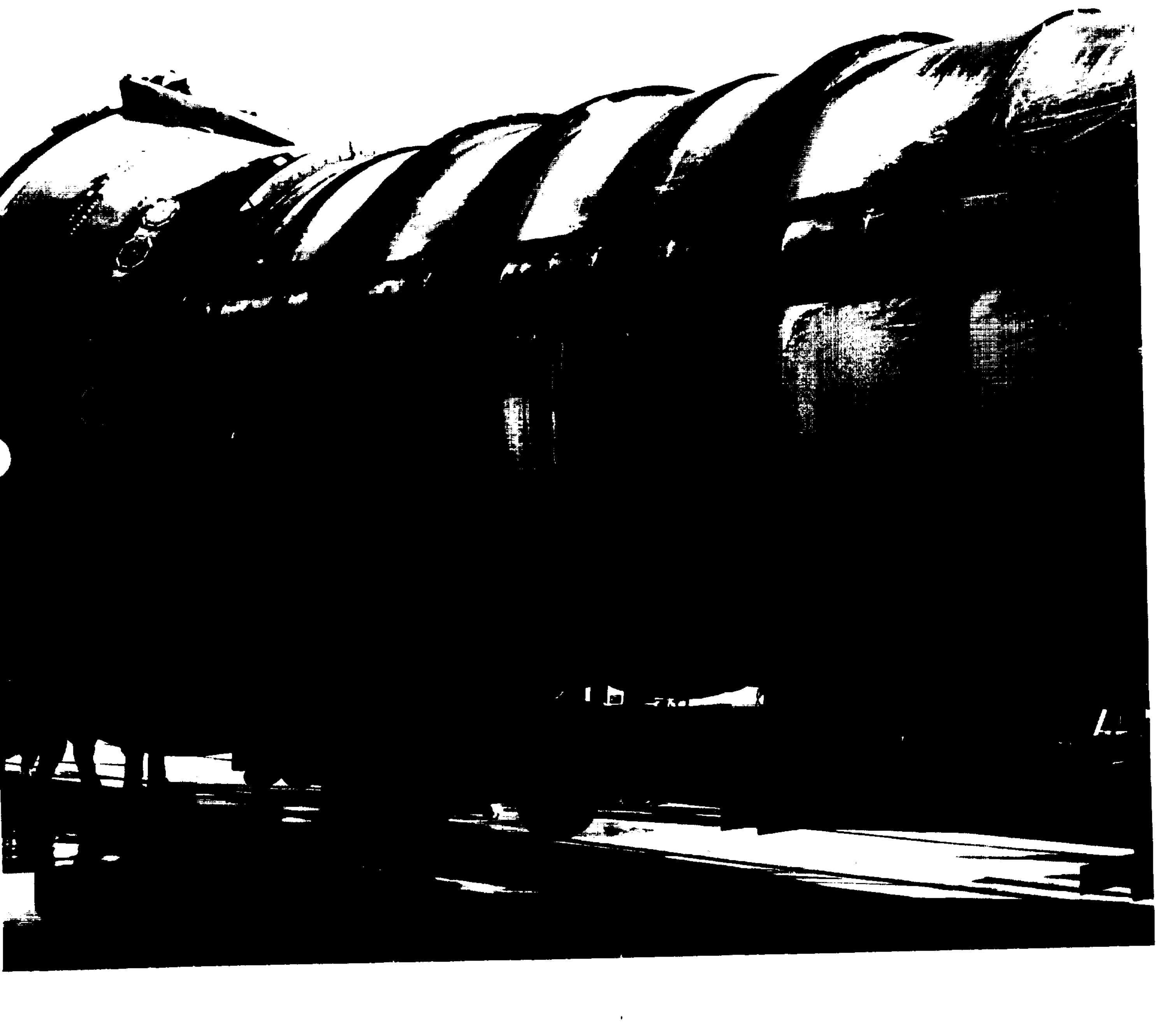
FIGURE 12. **LEFT SRB AFT SKIRT EXTERIOR TPS**





The LH frustum was missing no TPS, but had a total of 20 MSA-2 debonds. The BSM aero heat shield covers were locked in the fully opened position.

Dark marks on the LH SRB aft center segment during the launch countdown were still visible and appeared to be field joint closeout grease.



Post flight condition of the aft booster and aft skirt. The ET/SRB aft struts, ETA ring, IEA, IEA covers, and aft booster stiffener rings appeared undamaged.

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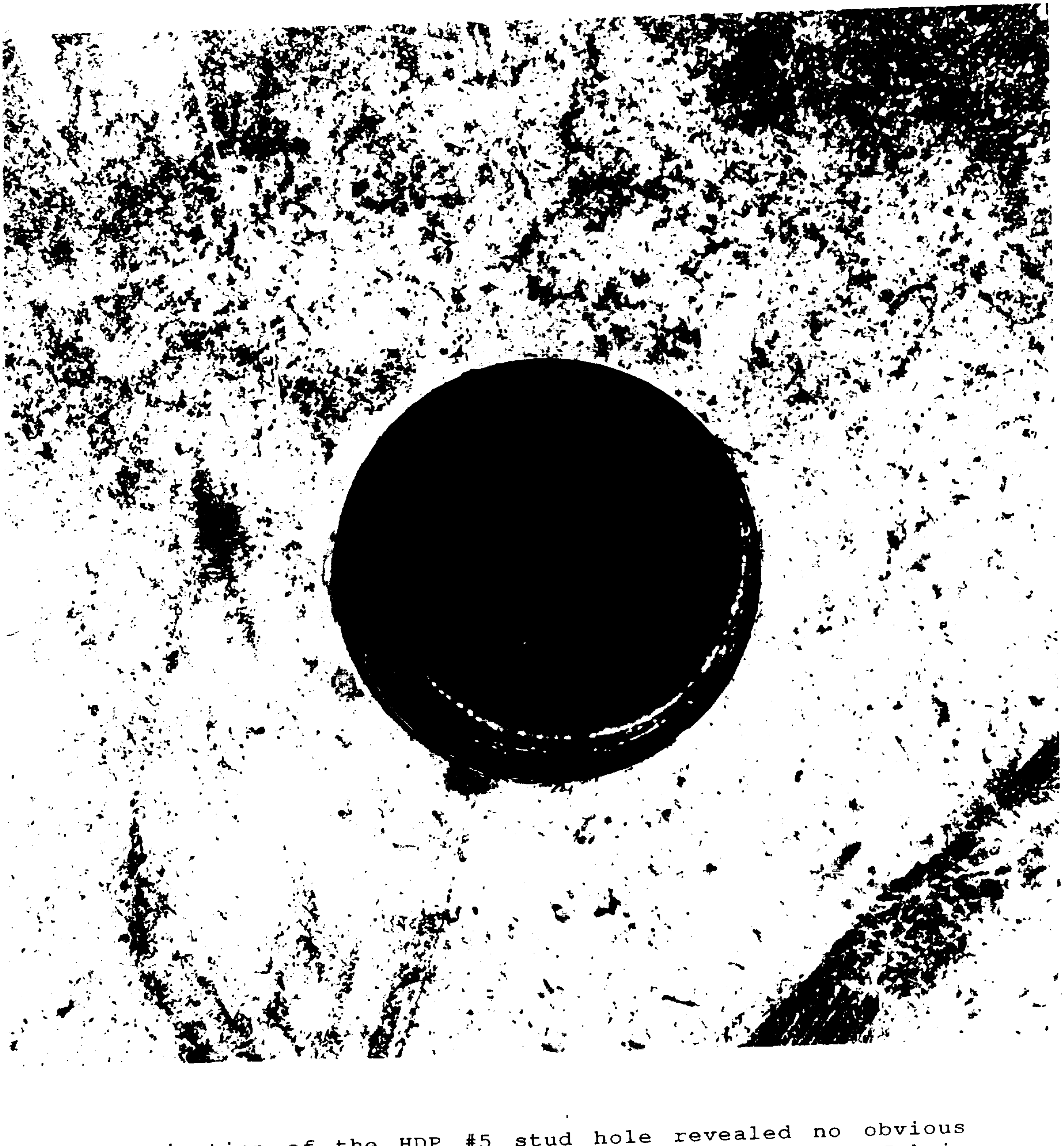

Examination of the HDP #5 stud hole revealed no obvious broaching or unusual abrasions due to the loss of the Debris Containment System (DCS) plunger/spring. The frangible nut halves were contained in the DCS housing.

ORIGINAL PAGE
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7.3 RECOVERED SRB DISASSEMBLY FINDINGS

Significant blistering of the Hypalon paint top layer had occurred on the RH frustum in an area between the -Y and +Y axes from the BSM's to the 395 ring frame. No sooting or charring was visible in the open paint blisters or on the Hypalon basecoat. Although Hypalon blistering is an accepted condition over MTA per 10MNL-0035, SRB Post Flight Assessment Manual, significant blistering over MSA-2 had not occurred previously and was squawked (56-004). Pre-flight documentation showed a solvent and phenolic microballoon mixture had been spilled during processing. The blistering was the result of subsequent cleaning and application of an additional layer of Hypalon topcoat over a fully cured Hypalon basecoat (reference USBI Report No. RWR-045-93MP, dated 17 May 1993).

The RH forward skirt acreage MSA-2 exhibited two debonds (3 and 1.5 inches in diameter, respectively) near the ET/SRB attach fitting. The two debonds were dissected in place and no evidence was found to suggest the debonds were a pre-flight condition. The MSA-2 had failed cohesively within the MSA-2 and there appeared to be adequate adhesion of MSA-2 to substrate. USBI Report No. RWR-046-93MP, dated 17 May 1993, concluded the two debonds were random occurrences and were the combined result of pressure changes during descent and the tendency of the porous MSA-2 to vent.

STS-56 was the fourteenth flight to utilize the new "optimized" frangible links in the holddown post DCS's. The link was designed to increase the DCS plunger velocity and improve the seating alignment while leaving the stud ejection velocity the same. The design was intended to prevent ordnance debris from falling out of the DCS yet not increase the likelihood of a stud hang-up. According to NSTS-07700, the Debris Containment System should retain a minimum of 90 percent of the ordnance debris.

A recent change to the disassembly procedures by SRB Project (DCN 009 10MNL-0035) eliminated the weighing of frangible nut pieces and ordnance fragments in the DCS containers unless:

1) debris is observed in the launch films

2) the DCS plunger has an anomalous appearance during disassembly

3) visual inspection of the expected DCS contents reveals the absence of any pieces

Due to the HDP #5 DCS plunger anomaly, the contents of DCS #5 (discrepant) and DCS #6 (control) housings were weighed. A total of 0.707 pounds of debris were lost from the HDP #5 DCS compared to 0.020 pounds from the HDP #6 DCS.

HDP #	% of Nut without 2 Large Halves	% of Ordnance Fragments	% Overall
5	52	56	53
6	99	98	99

The current failure scenario suggests the frangible nut halves rebounded off the lead liner, symmetrically contacted the plunger assembly, and caused localized deformation to the plunger, which in turn allowed the plunger to pass through the stud hole (ref Figure 13). Once clear of the aft skirt/DCS housing, the plunger and spring became debris that could have been deflected by SRB plume impingement resulting in a potential threat to the vehicle. In this case, the frangible link connecting the plunger to the stud survived the launch environment.

Although a Rockwell-MSFC study calculated low probabilities for DCS debris to impact flight hardware, the Shuttle program acknowledged the potential threat by authorizing/funding the Debris Containment System. However, the study was based upon the size of expected ordnance debris objects (NSI cartridges and frangible nut webs). The presence of a larger, more massive, debris object (plunger and spring) in the launch environment is not acceptable. Should this failure occur again, the DCS plunger may have to be modified or redesigned.

Diagonal-cutting pliers fell out of the HDP #4 DCS area and were most likely wedged between the DCS housing and the RH aft skirt forged foot web for flight. The lost tool had been reported prior to launch, but no search was performed. The tool control plan will be changed to add specific instructions to be followed when a tool is reported missing or lost, final area inspections will be modified, and a retraining program for pad workers will be conducted.

SRB Post Launch Anomalies are listed in Section 10.

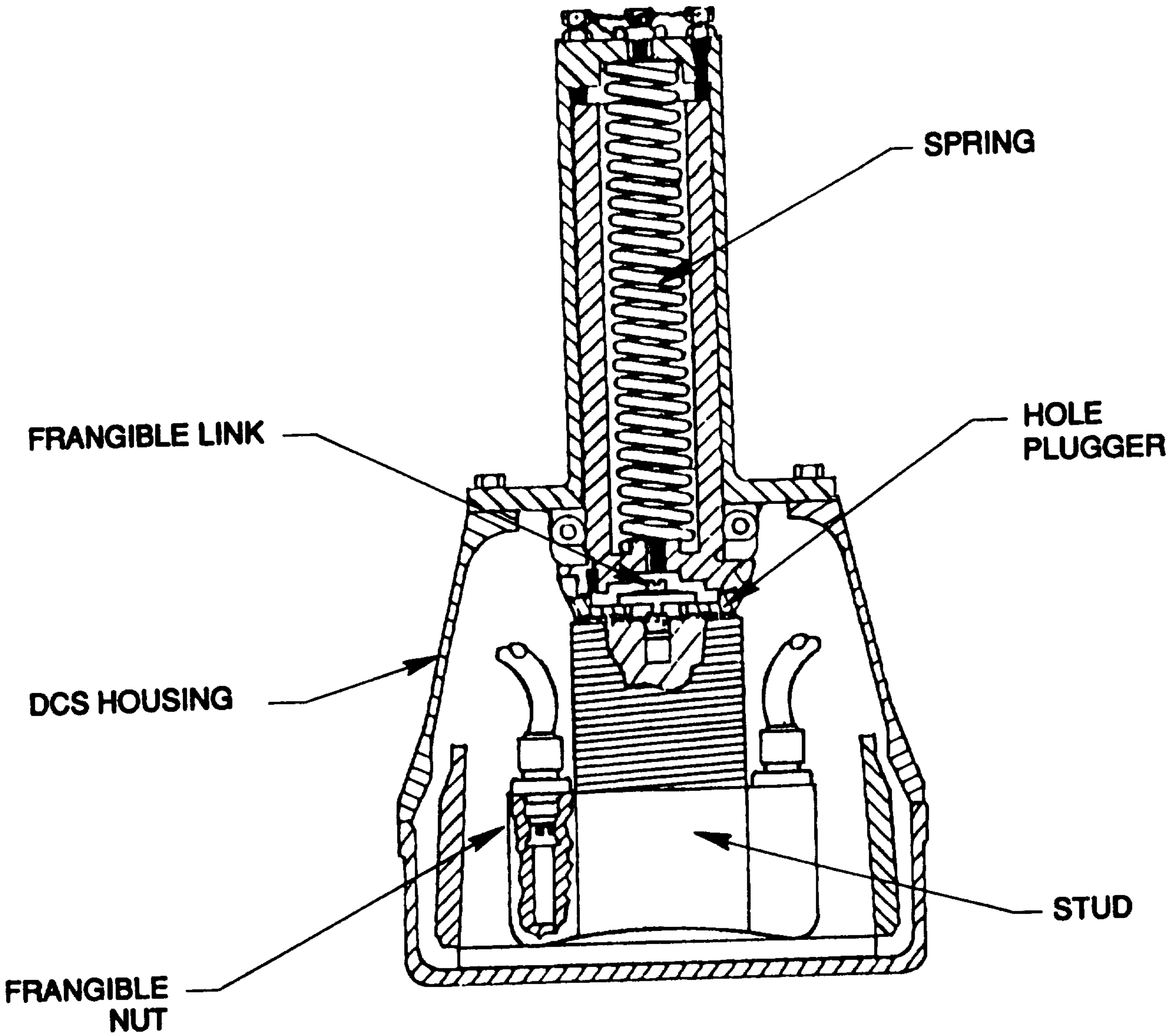
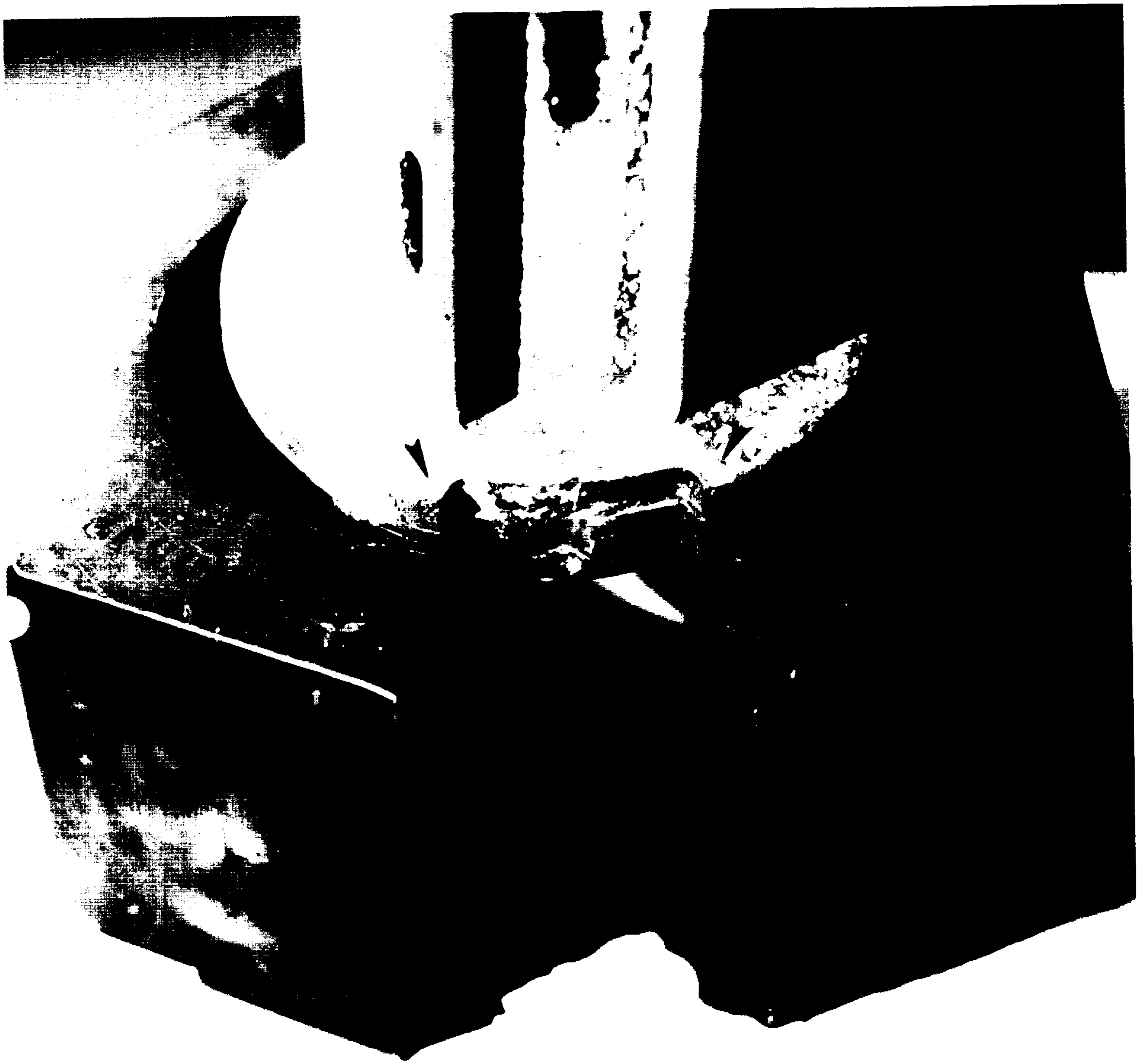


Figure 13. DEBRIS CONTAINMENT SYSTEM (DCS)



View showing frangible nut halves symmetrically contacting a DCS plunger assembly/hole plugger test article. The points of contact on the flight article had been materially deformed allowing the hole plugger/spring to exit the stud hole.

8.0 ORBITER POST LANDING DEBRIS ASSESSMENT

A post landing debris inspection of OV-103 (Discovery) was conducted 17-18 April 1993 at the Kennedy Space Center on Shuttle Landing Facility (SLF) runway 33 and in the Orbiter Processing Facility bay #3. This inspection was performed to identify debris impact damage and, if possible, debris sources. The Orbiter TPS sustained a total of 156 hits, of which 36 had a major dimension of one inch or greater. This total does not include the numerous hits on the base heat shield attributed to SSME vibration/acoustics and exhaust plume recirculation. A comparison of these numbers to statistics from 38 previous missions of similar configuration (excluding missions STS-23, 24, 25, 26, 26R, 27R, 30R, and 42, which had damage from known debris sources), indicates that the total number of hits is near average and the number of hits one inch or larger is greater than average (reference Figures 14-17).

The Orbiter lower surface sustained a total of 94 hits, of which 18 had a major dimension of one inch or greater. The distribution of hits on the lower surface does not suggest a single source of ascent debris, but indicates a shedding of ice and Thermal Protection System (TPS) debris from random sources.

The following table breaks down the STS-56 Orbiter debris damage by area:

	HITS > 1"	TOTAL HITS
Lower surface	18	94
Upper surface	2	23
Right side	0	0
Left side	0	0
Right OMS Pod	1	4
Left OMS Pod	15	35
TOTALS	36	156

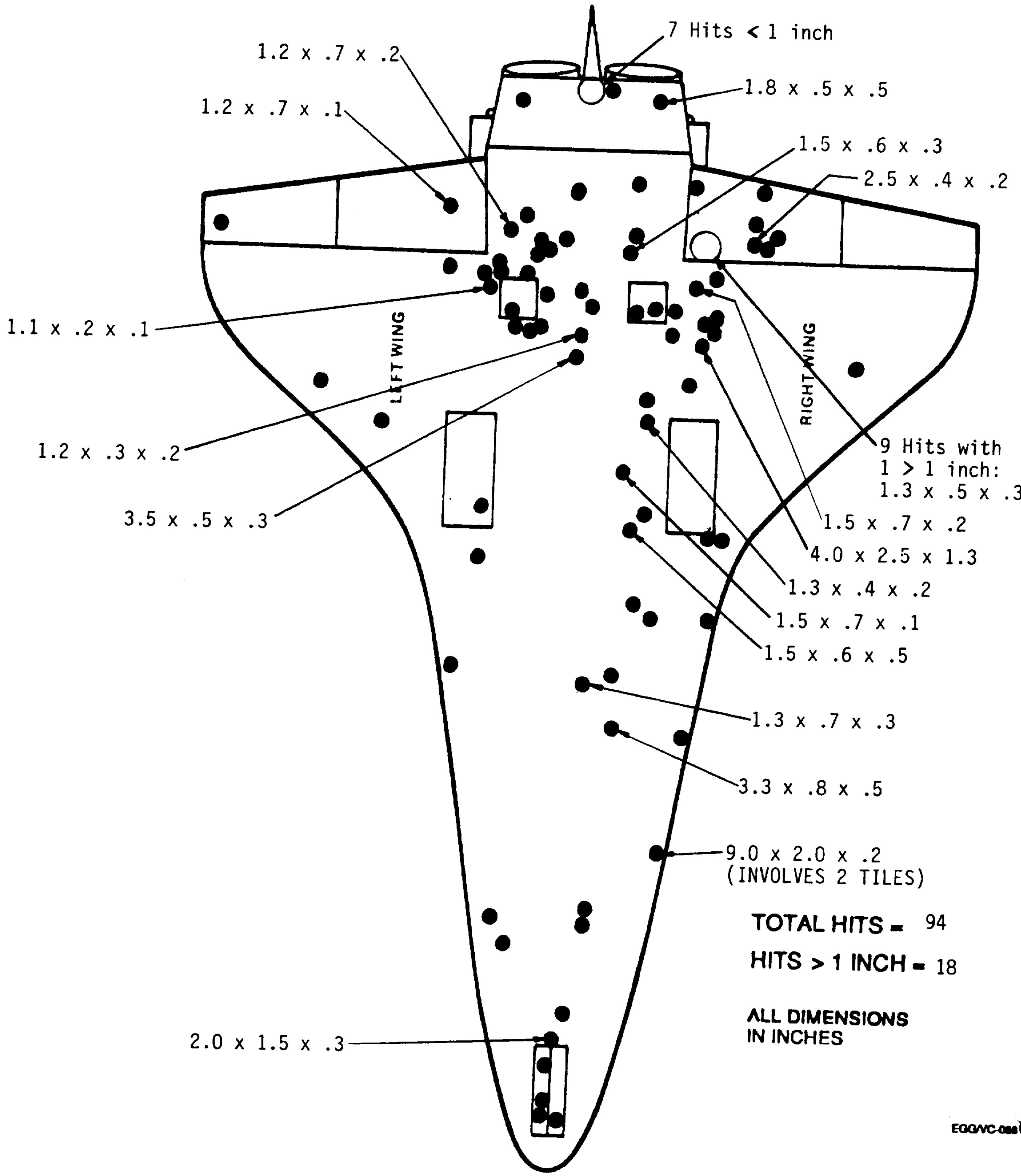
The largest tile damage site measured 9.0" x 2.0" x 0.2" (involving two tiles) and was located on the lower surface of the RH wing leading edge extension (glove area). The shallow depth of 0.2 inches is indicative of an impact by low density material, such as ET SOFI.

Four tiles, roughly in a fore-to-aft line on the Orbiter lower surface opposite the ET LO2 feedline sustained damage to a depth of 0.5 inches, or greater, that may be indicative of impacts from higher density materials, such as ice.

A loose gap filler was visible at the aft lower right corner of the body flap. Protrusion of the gap filler into the air flow caused some fusing of the material to an adjacent tile OML.

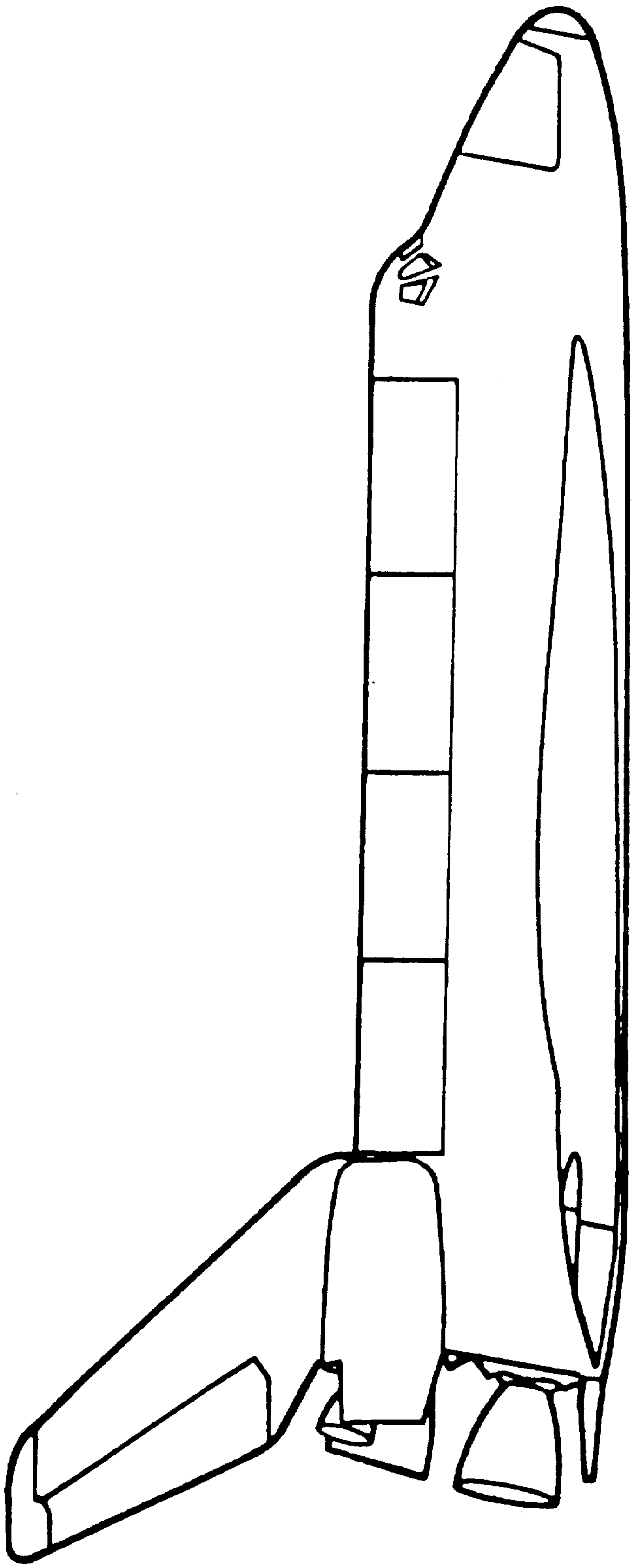
STS-56

FIGURE 14. DEBRIS DAMAGE LOCATIONS



STS-56

FIGURE 15. **DEBRIS DAMAGE LOCATIONS**

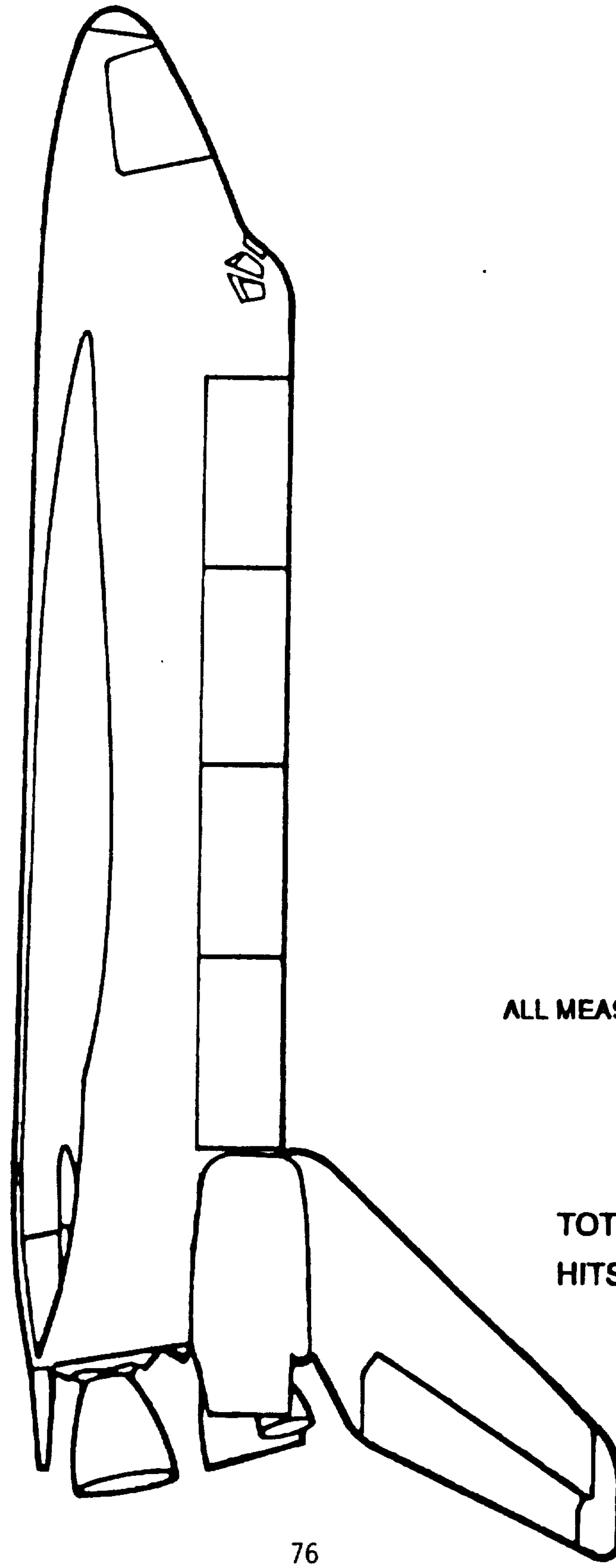


TOTAL HITS = 0

HITS > 1 INCH = 0

STS-56

FIGURE 16. DEBRIS DAMAGE LOCATIONS



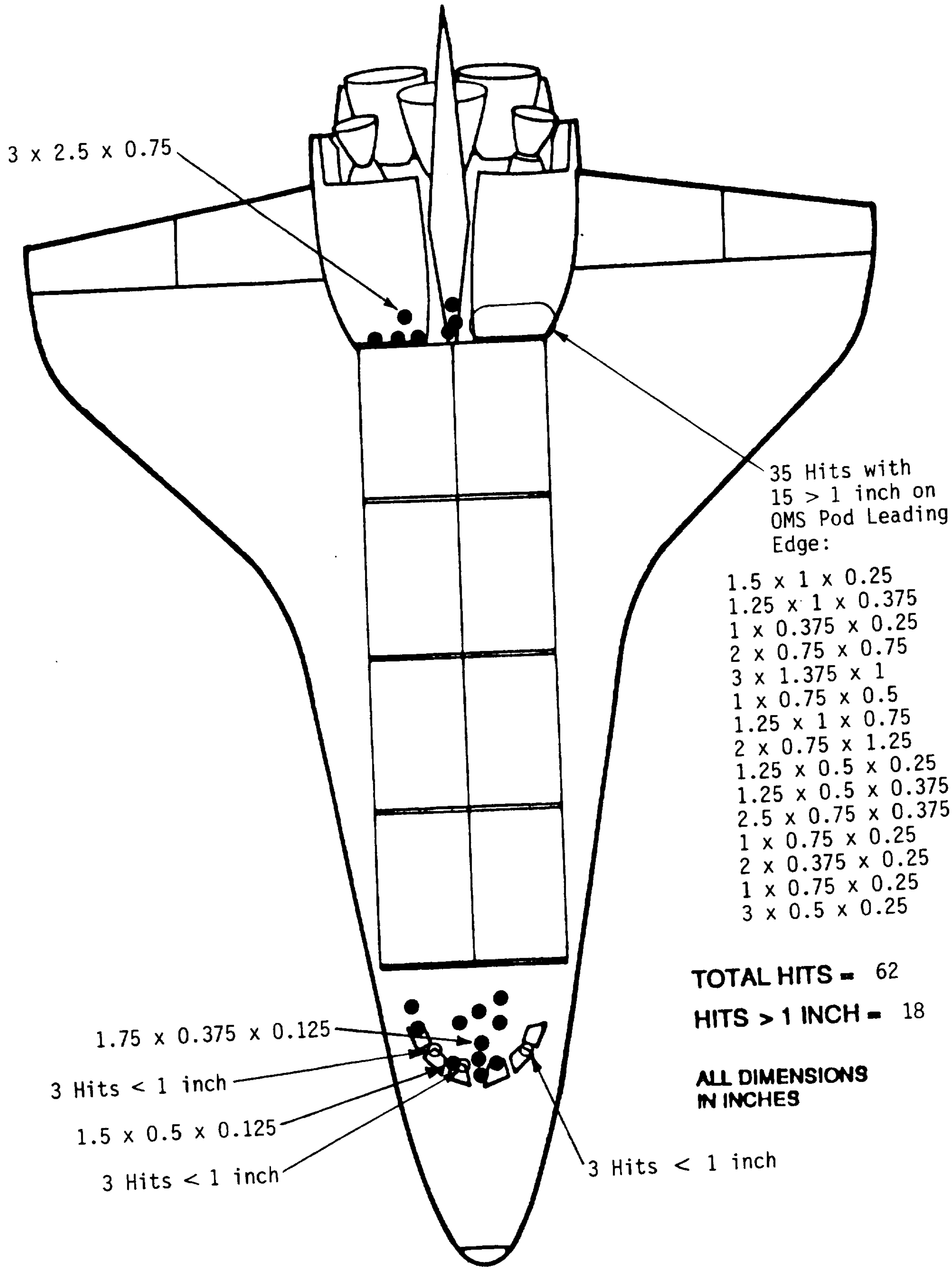
ALL MEASUREMENTS IN INCHES

TOTAL HITS = 0

HITS > 1 INCH = 0

STS-56

FIGURE 17. **DEBRIS DAMAGE LOCATIONS**



No TPS damage was attributed to material from the wheels, tires, or brakes. The main landing gear tires were considered to be in good condition for a landing on the KSC runway.

All three ET/Orbiter separation devices (EO-1, 2, 3) appeared to have functioned properly. All ET/Orbiter umbilical separation ordnance retention shutters were closed properly. No flight hardware was found on the runway below the umbilicals when the ET doors were opened.

Orbiter windows #3 and #4 exhibited moderate hazing. Only a very light haze was present the other windows. Some streaks were visible on window #3 and #4. Surface wipes were taken from all windows for laboratory analysis (Figure 18).

Tile damage on the base heat shield was typical. A ring tile insert was missing/damaged on the SSME #1 engine mounted heat shield 6:30 o'clock position. Numerous, but small, areas of tile surface coating material were missing on the +Z side of the body flap along the hinge line. The SSME Dome Mounted Heat Shield (DMHS) closeout blanket sacrificial panels were intact and in excellent condition.

The tiles on the LH OMS pod leading edge sustained more damage than usual (at least 35 hits, of which 15 had a major dimension of 1 inch or greater). Several of the tile damage sites reached a depth ranging from 0.5 to approximately 1.25 inches. The cause of this damage is believed to be ice from the waste water dump nozzle near the crew hatch. STS-53 was the last mission to sustain greater than average tile damage on the LH OMS pod leading edge (27 hits total; 10 hits 1-inch or greater).

Runway 33 had been swept/inspected by SLF operations personnel prior to landing and all potentially damaging debris was removed.

The post landing walkdown of Runway 33 was performed immediately after landing. Two pieces of Q-felt plug, most likely from the base heat shield, were found along the runway centerline at the 5010 foot marker. No organic (bird) debris or non-flight hardware was found on the runway.

Eight pieces of black tile, the largest of which measured 5.25" x 1.25" x 1.0", were recovered between the 5400 to 8080 foot runway markers. These tile fragments originated from the rudder/speed brake "stinger", which is an area damaged on previous uses of the drag chute by contact with the parachute riser lines. This flight marked the seventh use of the Orbiter drag chute. Aside from the damage to the vertical stabilizer stinger, the drag chute appeared to have functioned nominally. All drag chute hardware was recovered and appeared to be in good condition (Figure 19).

STS-56

FIGURE 18. **CHEMICAL SAMPLE LOCATIONS**

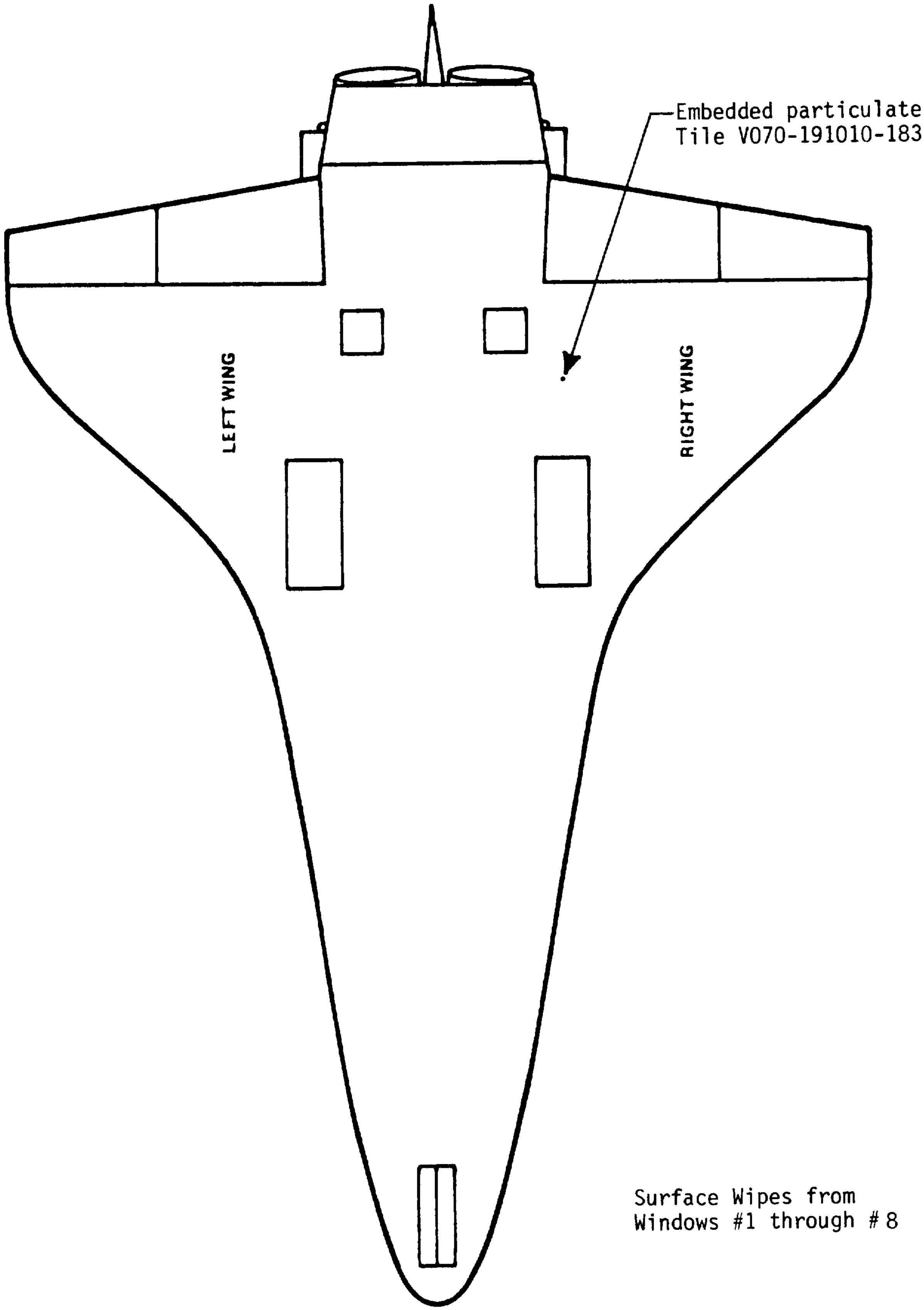
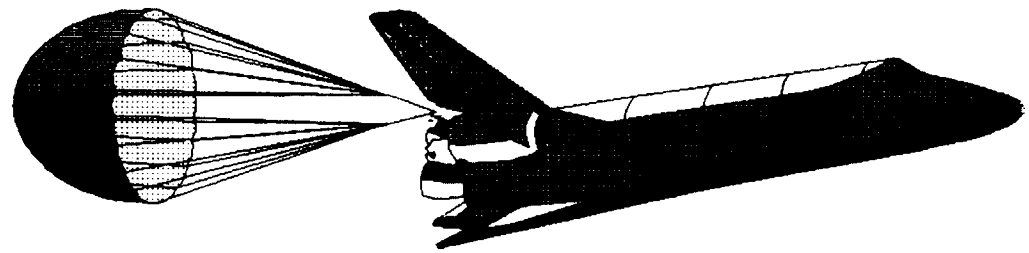
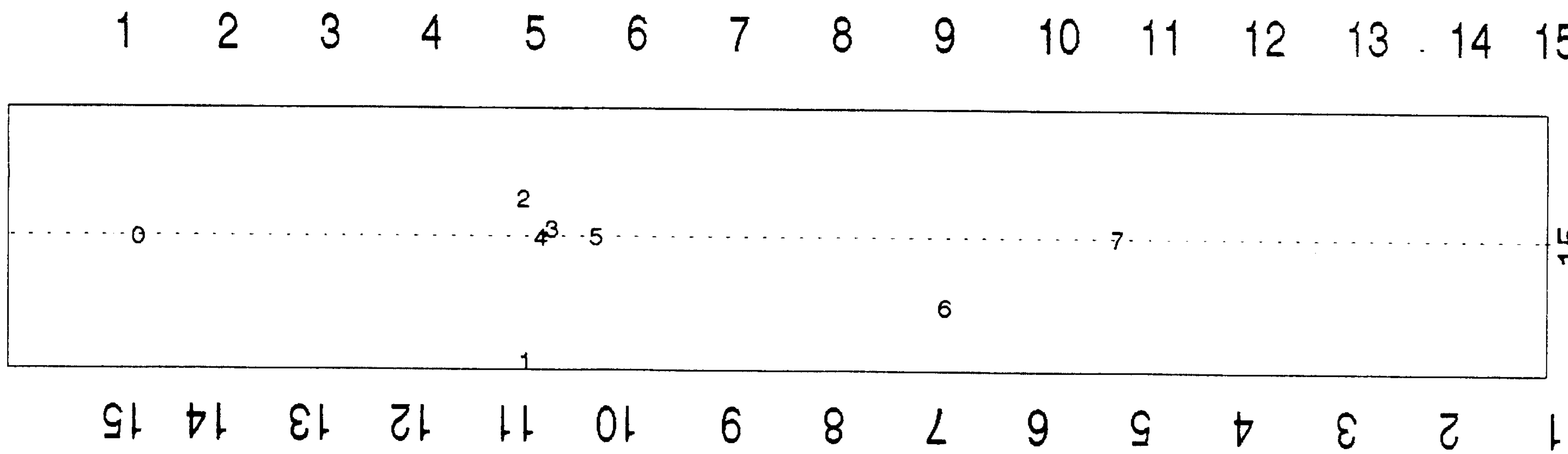


FIGURE 19.

RECOVERY LOCATIONS OF DRAG CHUTE COMPONENTS





0 (MLG TOUCHDOWN): 1074'
1 (MORTAR COVER): 4960 147' E OF C/L
2 (SABOT): 4980', 23' W OF C/L
3 (DOOR): 5065', 7' W OF C/L
4 (PILOT CHUTE): 5030', ON C/L
5 (NLG TOUCHDOWN): 5587'
6 (MAIN CHUTE): 9005', 70' E OF C/L

STS-56
OV-103DISCOVERY
4/17/93

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A portable Shuttle Thermal Imager (STI) was used to measure the surface temperatures of three areas on the Orbiter (per OMRSD V09AJ0.095). Ten minutes after landing, the Orbiter nosecap RCC was 202 degrees Fahrenheit (F). Twenty minutes after landing, the RH wing leading edge RCC panel #9 was 102 degrees F and panel #17 was 97 degrees F (Figure 20).

In summary, the total number of Orbiter TPS debris hits was near average and the number of hits one inch or larger was greater than average when compared to previous missions (Figures 21-22).

Orbiter Post Launch Anomalies are listed in Section 10.

FIGURE 20. **STS- 56 RCC TEMPERATURE MEASUREMENTS AS RECORDED BY THE SHUTTLE THERMAL IMAGER**

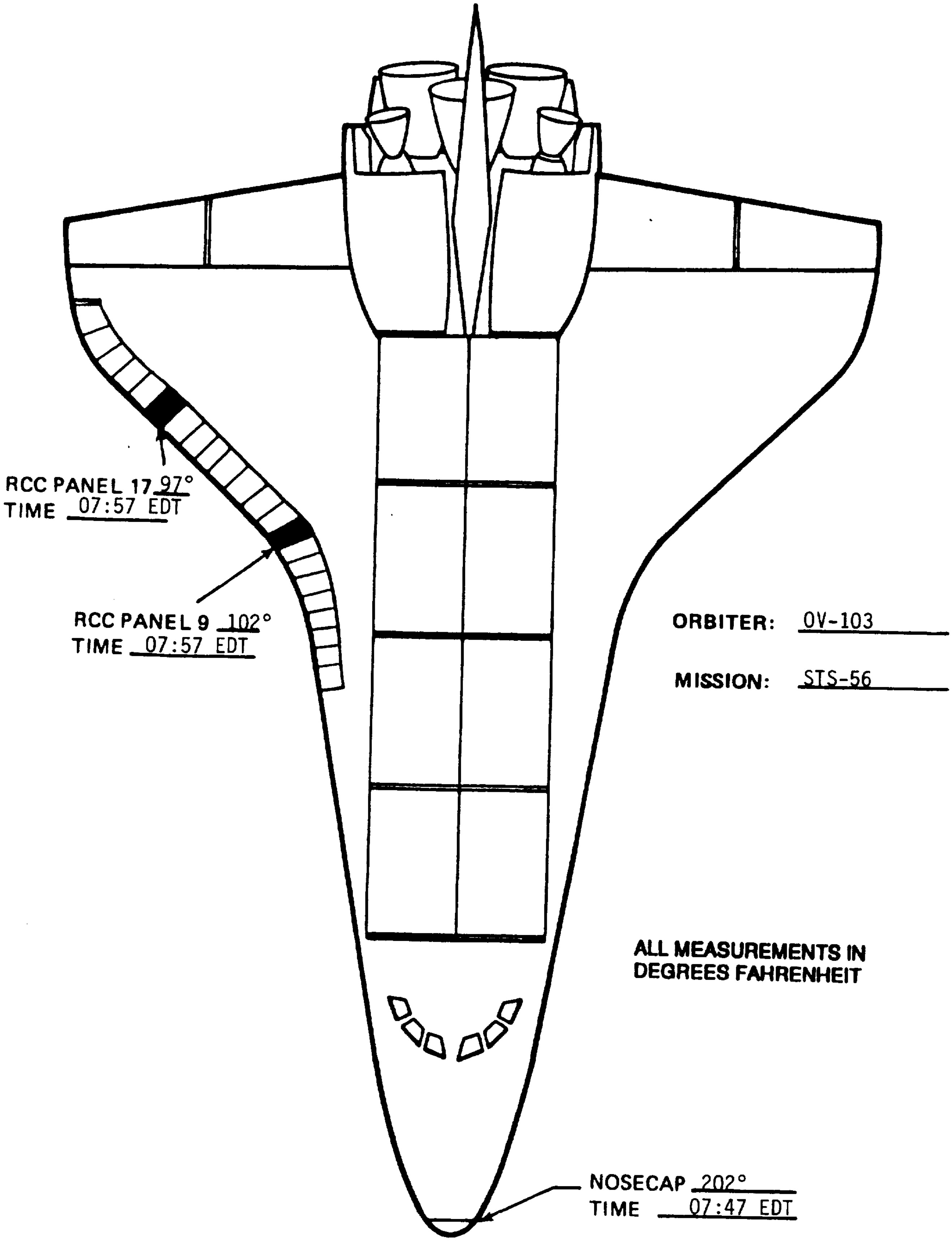
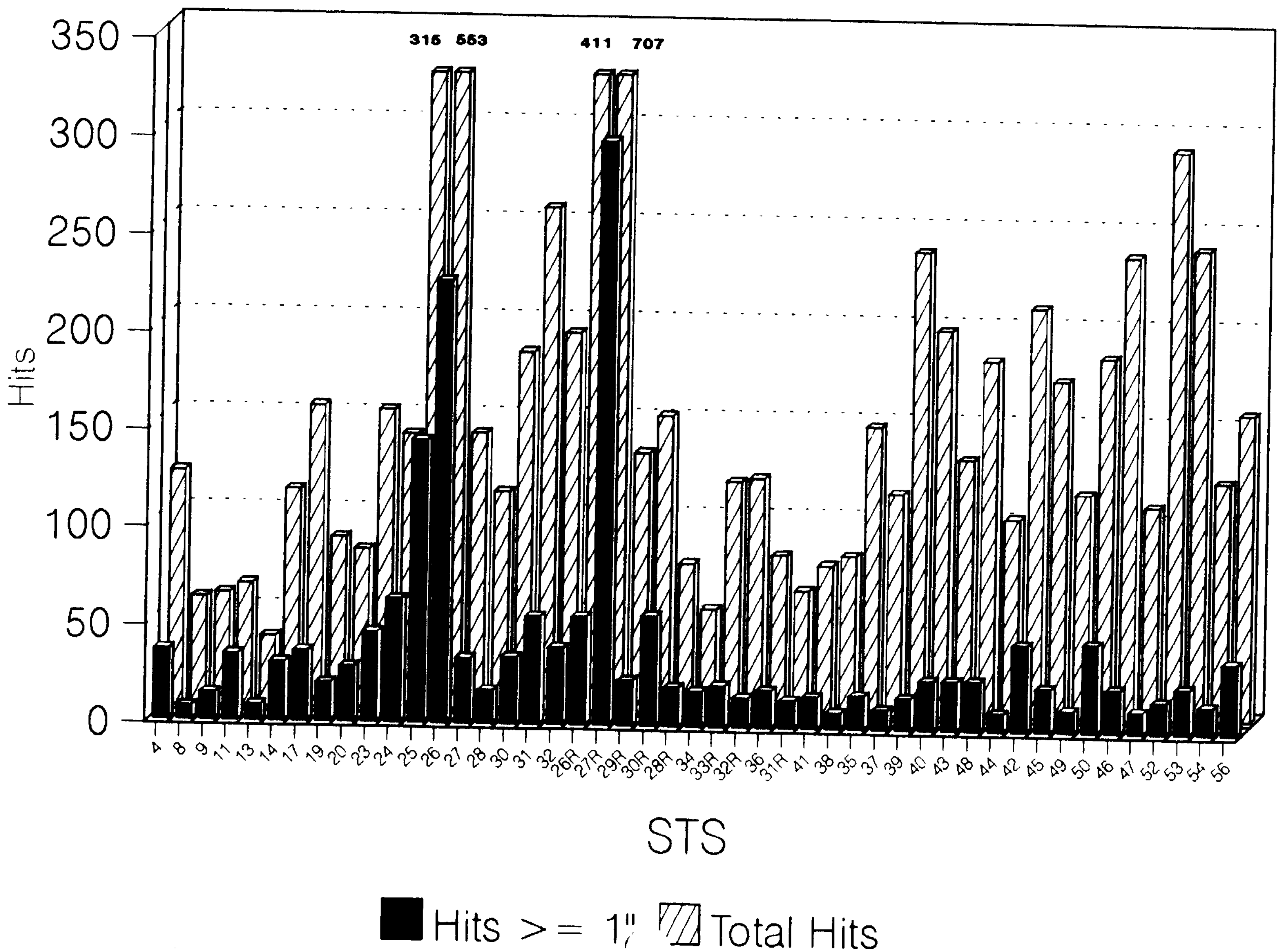


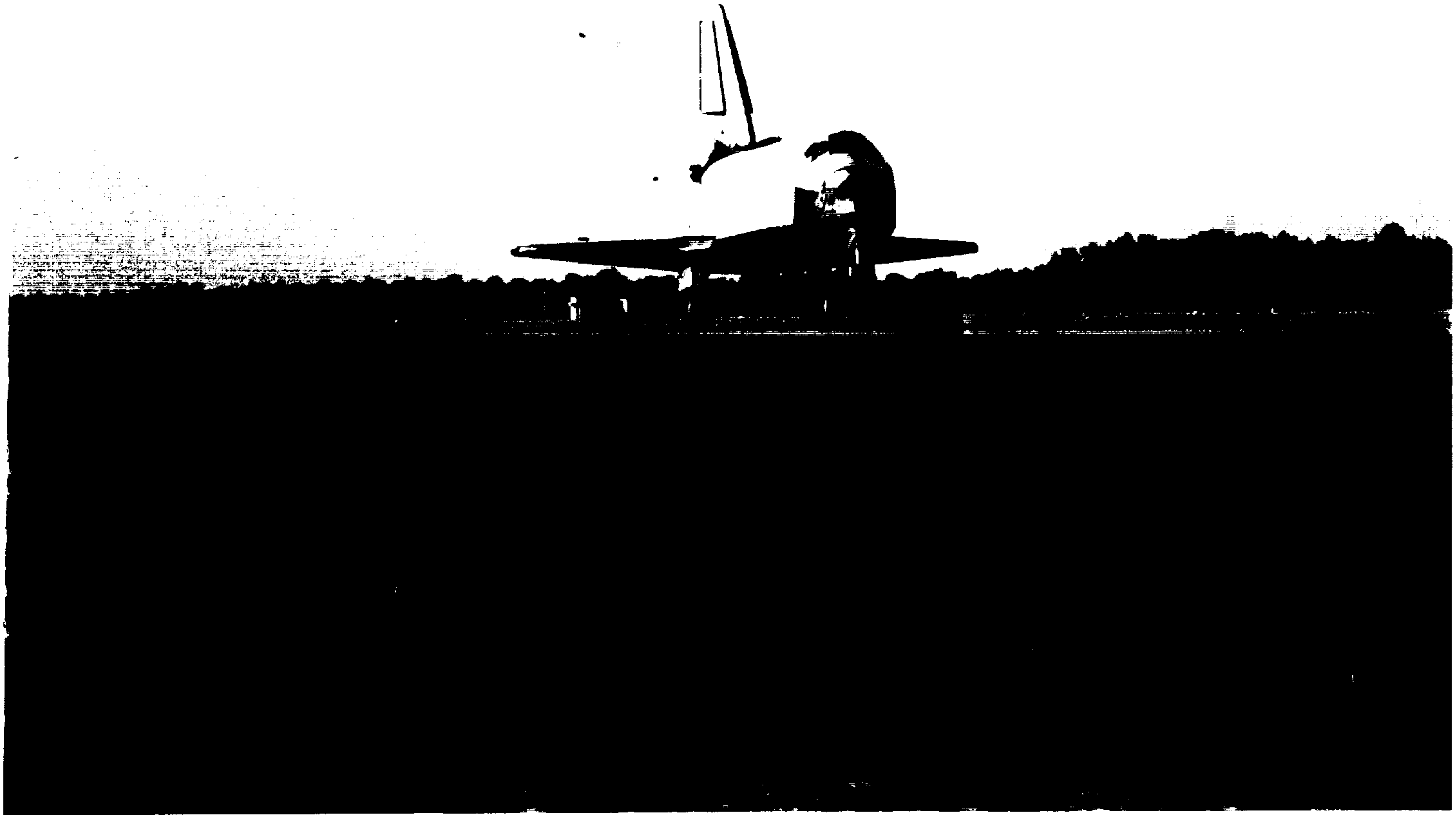
FIGURE 21. *ORBITER POST FLIGHT DEBRIS DAMAGE SUMMARY*

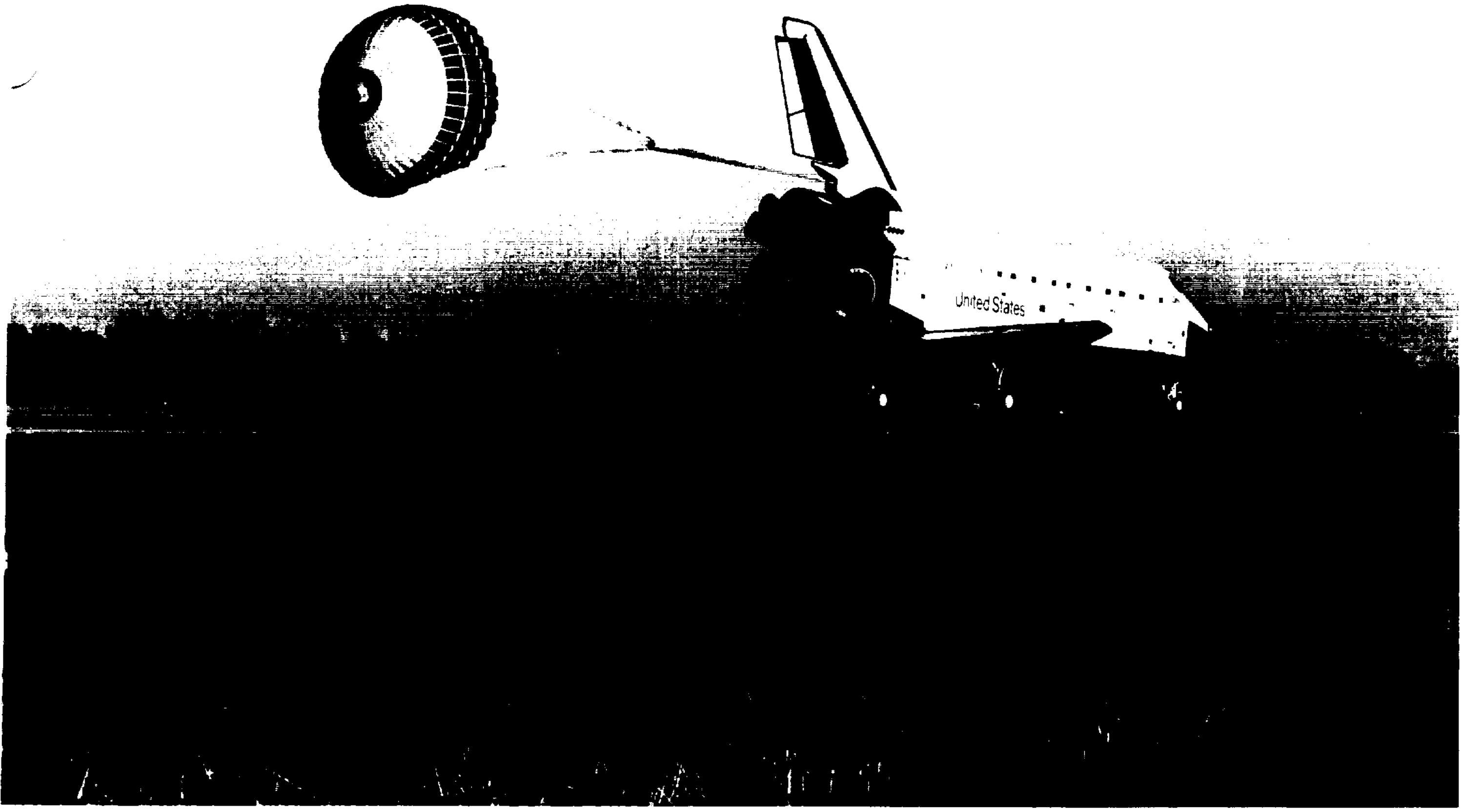
	LOWER SURFACE		ENTIRE VEHICLE	
	HITS > 1 INCH	TOTAL HITS	HITS > 1 INCH	TOTAL HITS
STS-6	15	80	36	120
STS-8	3	29	7	56
STS-9 (41-A)	9	49	14	58
STS-11 (41-B)	11	19	34	63
STS-13 (41-C)	5	27	8	36
STS-14 (41-D)	10	44	30	111
STS-17 (41-G)	25	69	36	154
STS-19 (51-A)	14	66	20	87
STS-20 (51-C)	24	67	28	81
STS-27 (51-I)	21	96	33	141
STS-28 (51-J)	7	66	17	111
STS-30 (61-A)	24	129	34	183
STS-31 (61-B)	37	177	55	257
STS-32 (61-C)	20	134	39	193
STS-29	18	100	23	132
STS-28R	13	60	20	76
STS-34	17	51	18	53
STS-33R	21	107	21	118
STS-32R	13	111	15	120
STS-36	17	61	19	81
STS-31R	13	47	14	63
STS-41	13	64	16	76
STS-38	7	70	8	81
STS-35	15	132	17	147
STS-37	7	91	10	113
STS-39	14	217	16	238
STS-40	23	153	25	197
STS-43	24	122	25	131
STS-48	14	100	25	182
STS-44	6	74	9	101
STS-45	18	122	22	172
STS-49	6	55	11	114
STS-50	28	141	45	184
STS-46	11	186	22	236
STS-47	3	48	11	108
STS-52	6	152	16	290
STS-53	11	145	23	240
STS-54	14	80	14	131
AVERAGE	14.7	93.2	22.0	132.5
SIGMA	7.5	46.6	10.8	62.5
STS-56	18	94	36	156

MISSIONS STS-23, 24, 25, 26, 26R, 27R, 30R, AND 42 ARE NOT INCLUDED IN THIS ANALYSIS SINCE THESE MISSIONS HAD SIGNIFICANT DAMAGE CAUSED BY KNOWN DEBRIS SOURCES

FIGURE 22. **COMPARISON TABLE**

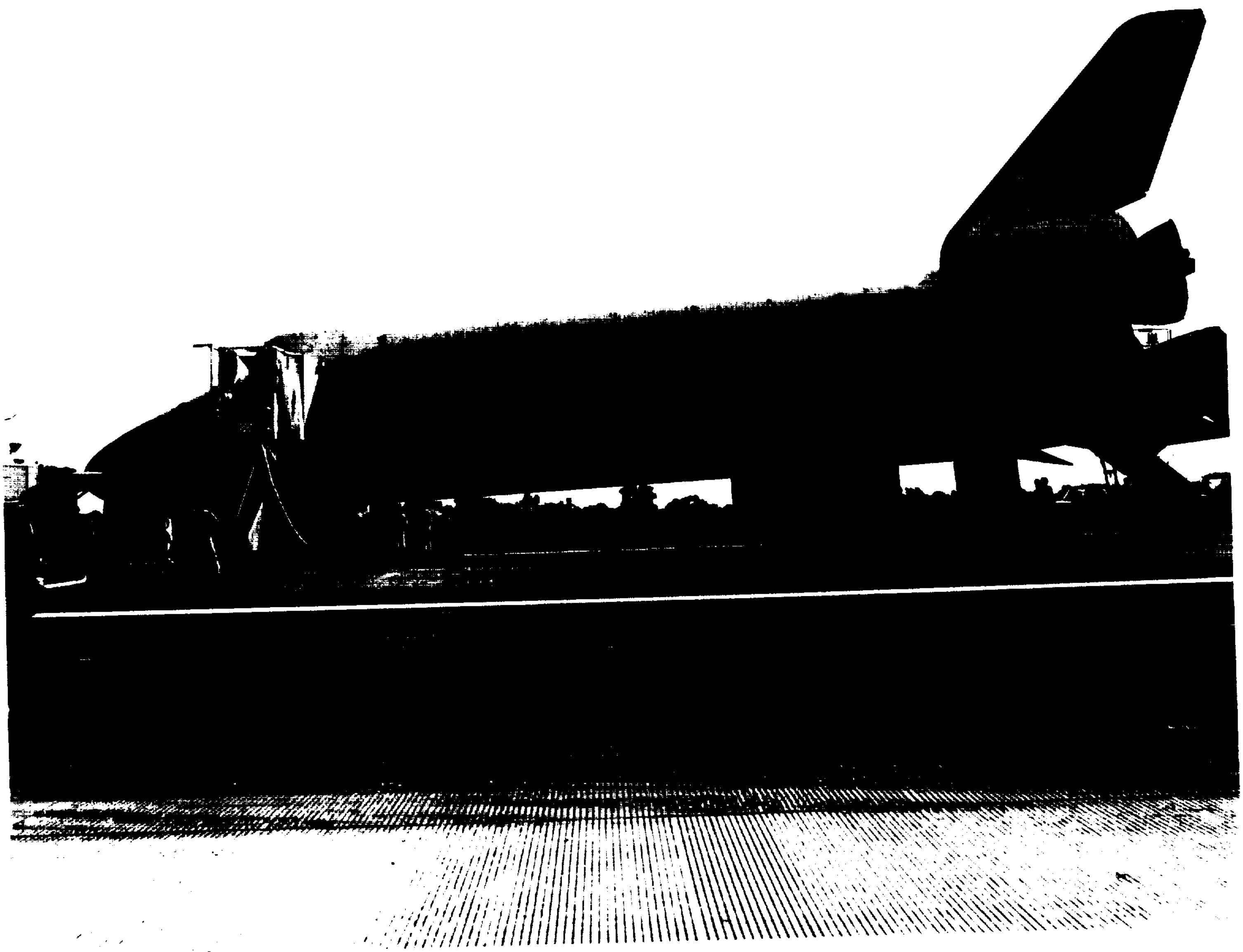




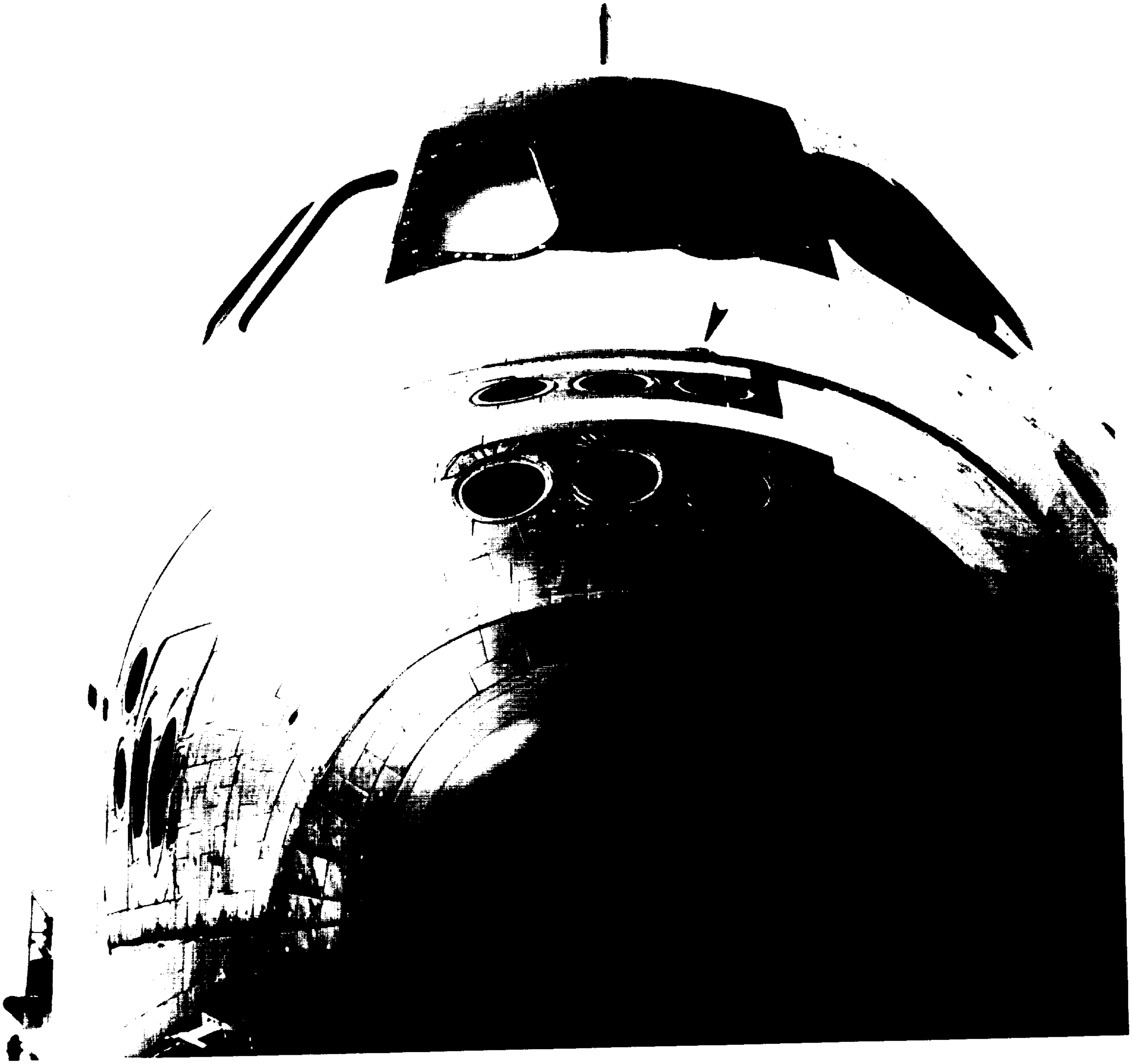


OV-103 Discovery made the 15th KSC landing on SLF Runway 33.
Operation and deployment of the drag chute was nominal.

Overall view of Orbiter right side



Overall view of Orbiter left side



Overall view of Orbiter nose. Note moderate hazing of forward facing windows and small damage sites on window perimeter tiles. Part of a AFRSI panel is loose aft of FRCS thruster F1U.

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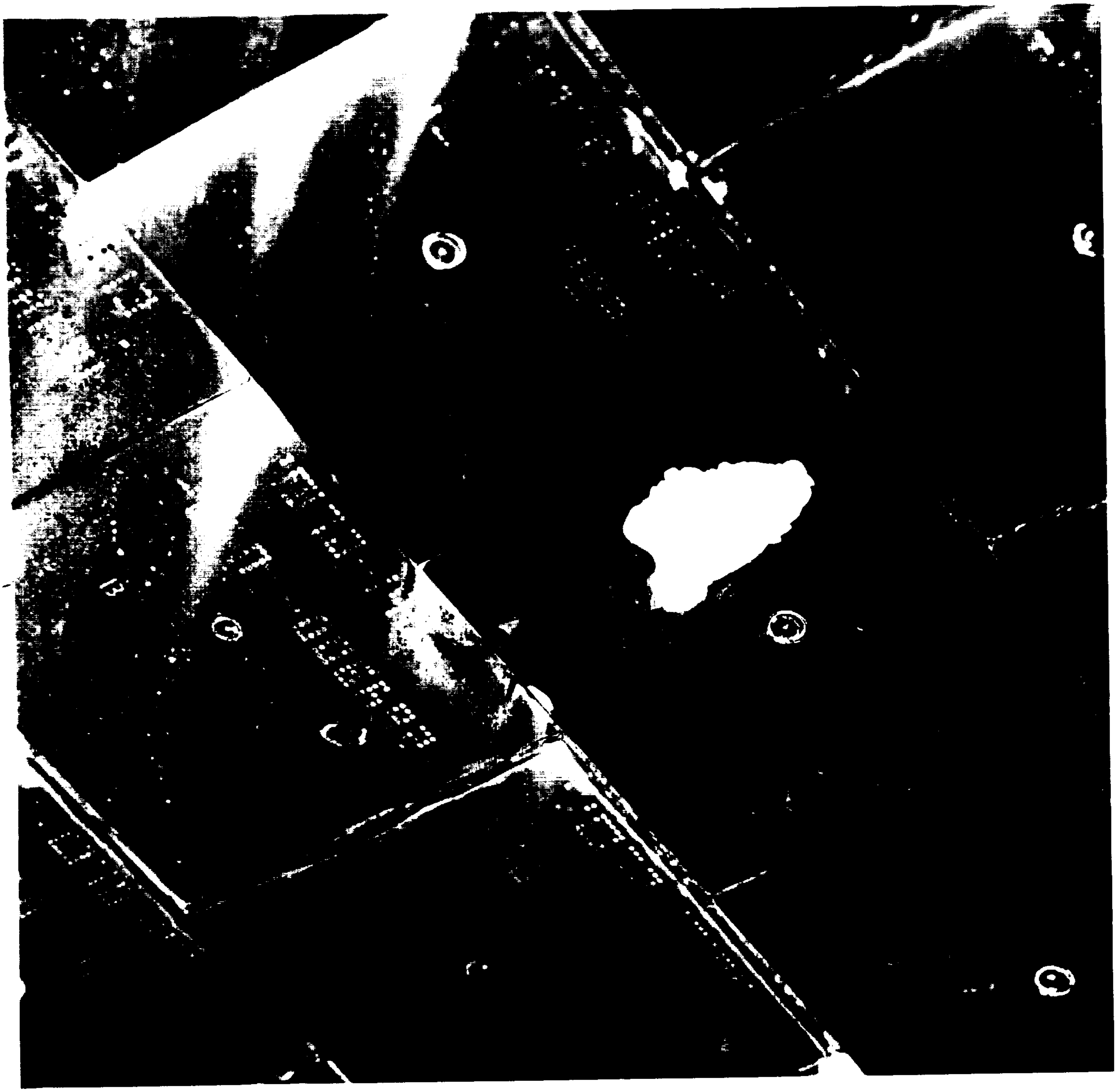
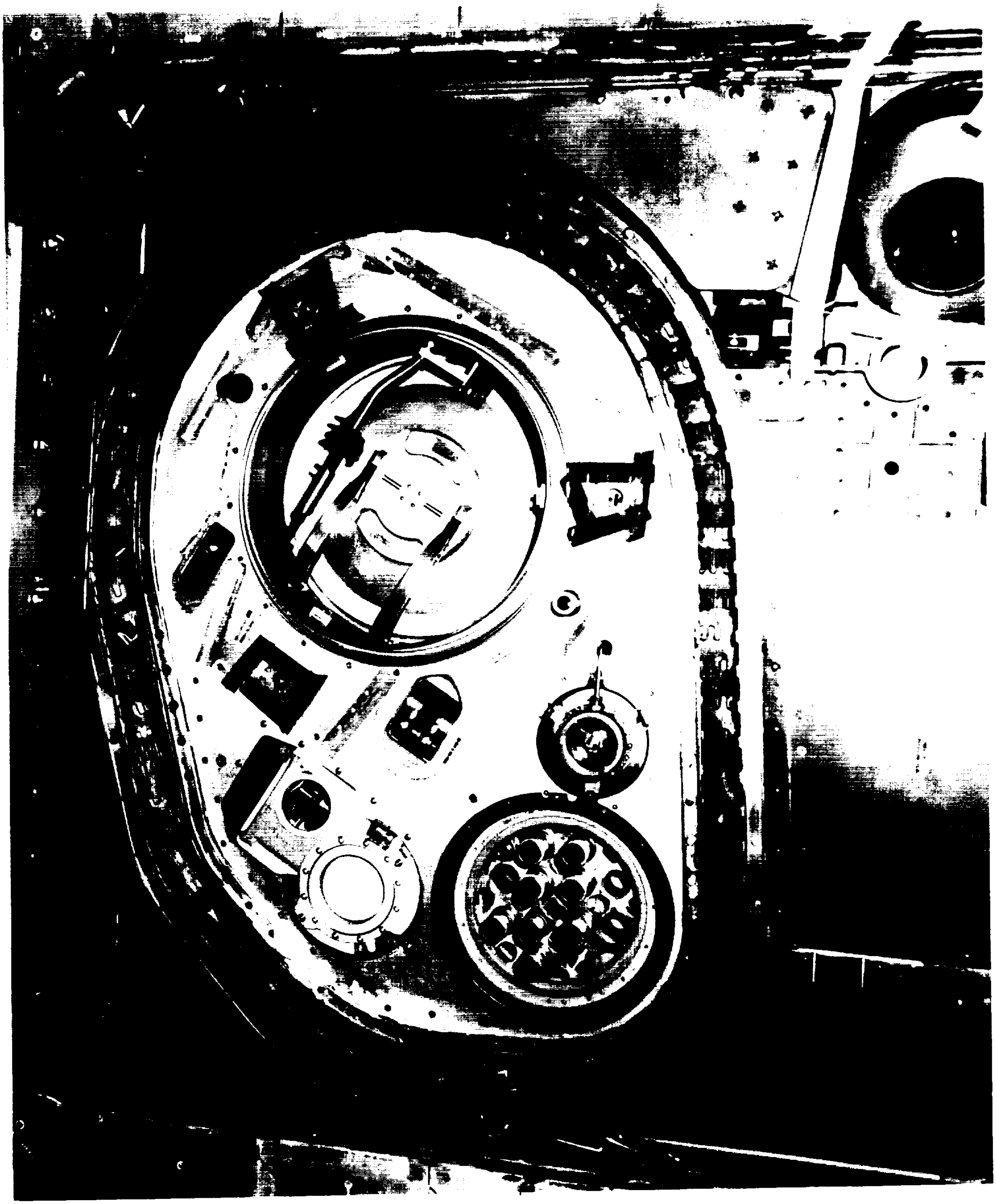
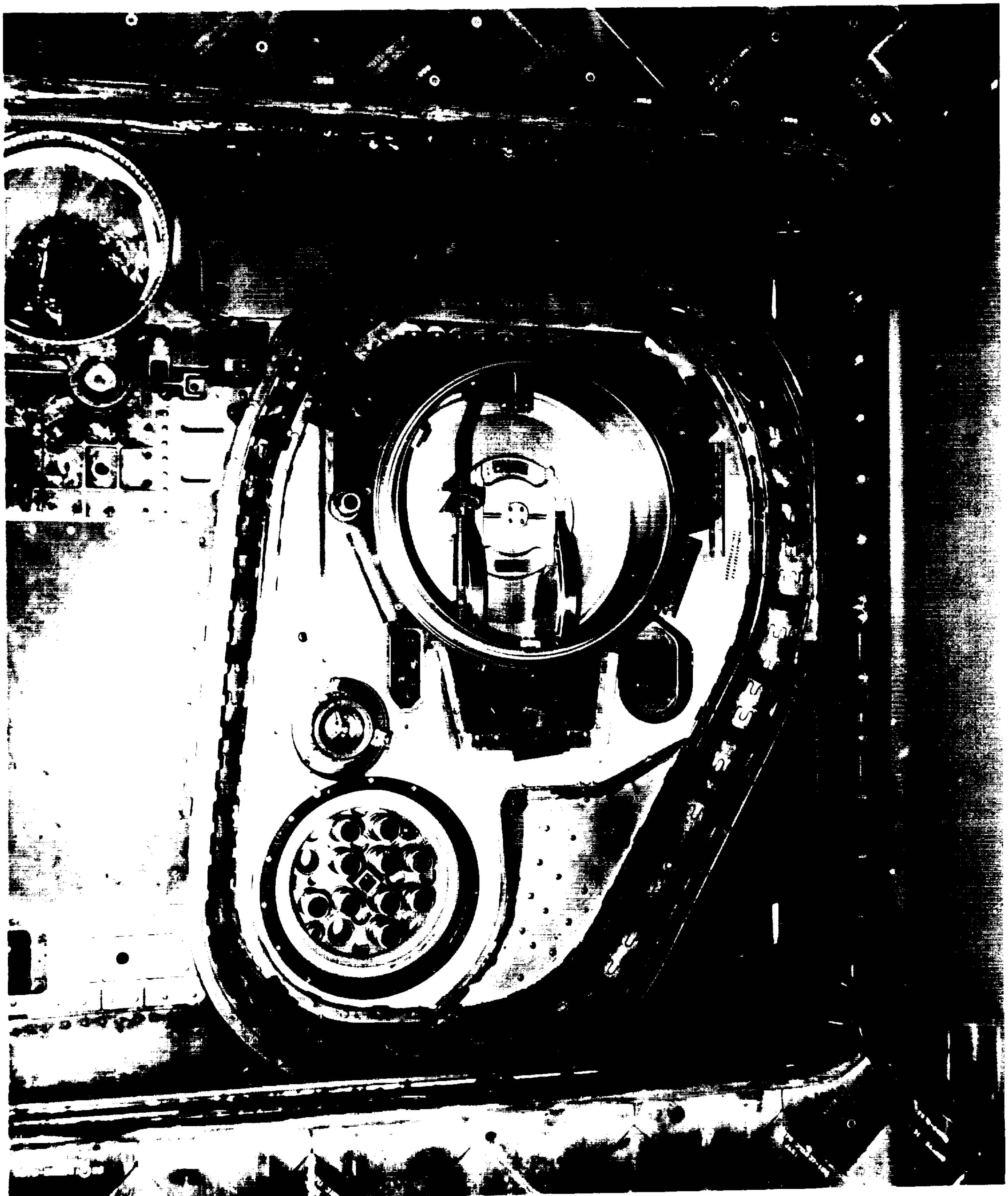


The Orbiter lower surface tiles sustained a total of 94 hits, of which 18 had a major dimension of 1-inch or greater.

The largest tile damage site measured 9" x 2" x 0.2" and was located on the lower surface of the RH wing leading edge extension. The shallow depth is indicative of an impact by low density material.

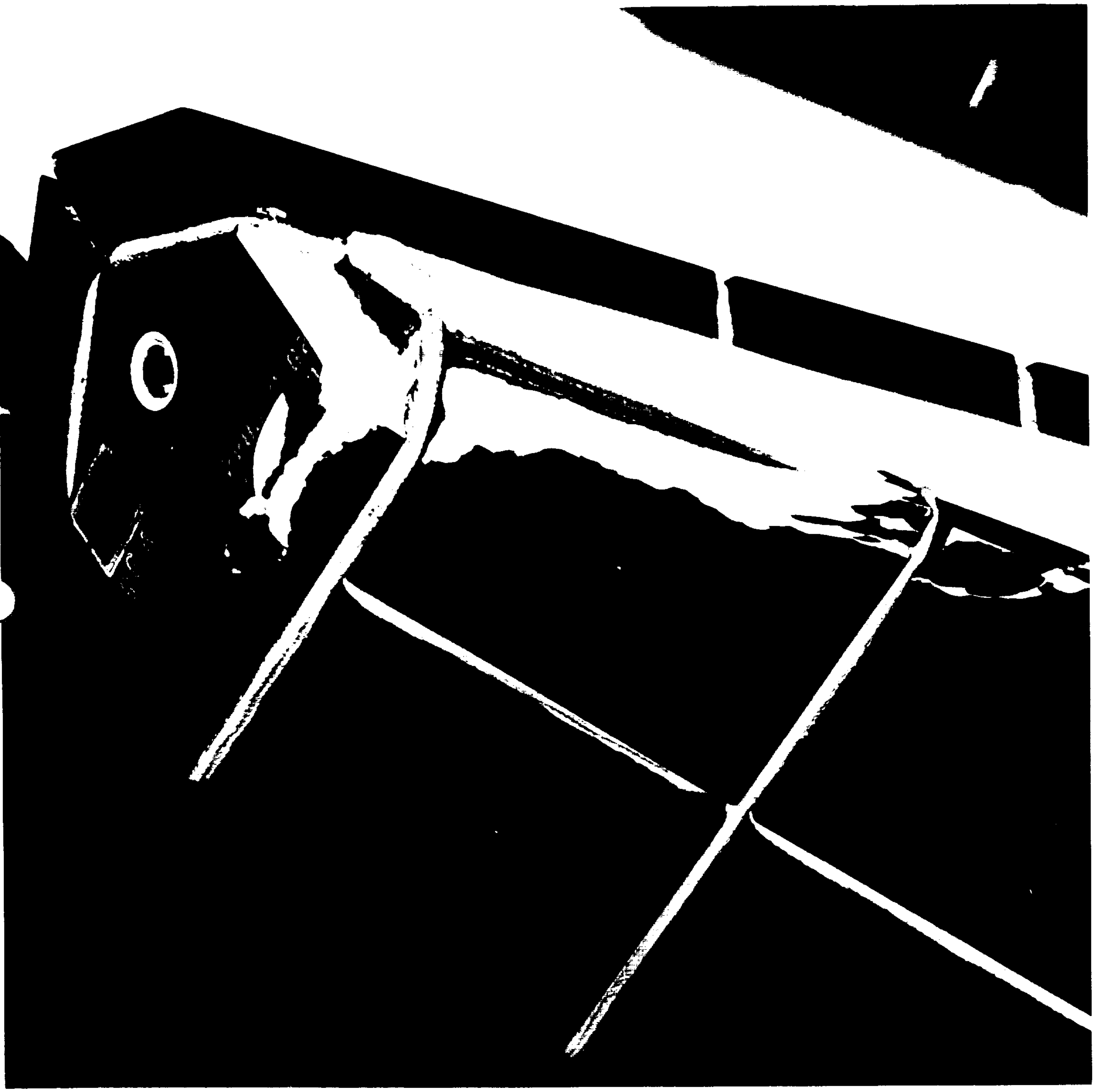


Overall view of the LH2 ET/ORB umbilical. All separation ordnance devices functioned properly. No flight hardware was found on the runway below the umbilical when the ET door was opened.



Overall view of the LO2 ET/ORB umbilical. All separation ordnance devices functioned properly. No flight hardware was found on the runway below the umbilical when the ET door was opened.

Tiles on the LH OMS pod leading edge sustained more damage than usual (35 hits, of which 15 had a major dimension of 1-inch or greater). Several of the damage sites reached a depth of 1.25 inches. The cause of this damage is believed to be ice from the waste water dump nozzle near the crew hatch.



Eight tile fragments found on the runway originated from the vertical stabilizer "stinger" and had been dislodged by contact with the drag chute riser lines during deployment.

9.0 DEBRIS SAMPLE LAB REPORTS

A total of nine samples were obtained from OV-103 Discovery during the STS-56 post landing debris assessment at Kennedy Space Center (reference Figure 18). The nine submitted samples consisted of 8 window wipes (Windows 1-8) and 1 tile damage site sample with embedded particulate. The samples were analyzed by the NASA KSC Microchemical Analysis Branch (MAB) for material composition and comparison to known STS materials. Debris analysis involves the placing and correlating of particles and residues with respect to composition, thermal (mission) effects, and availability. Debris sample results are shown in tabular form (Figure 23) and analyses are discussed by Orbiter location in the following summaries.

Orbiter Windows

Samples from the Orbiter windows indicated exposure to SRB BSM exhaust; Orbiter Thermal Protection System (TPS); paints and primer from various sources; landing site products; and organic materials. A finding that had been previously observed (STS-50 vertical stabilizer sample) was the presence of "E-glass." Carbon steel spheres, found in the STS-54 window samples, were also detected in this sampling set. Preliminary results of the organic material analysis indicate similar types of compounds as those previously noted. There was no apparent damage related to these residual findings.

Lower Surface Tile

The sample from the Orbiter lower surface tile damage site revealed exposure to Orbiter Thermal Protection System (TPS) materials only. The absence of material other than TPS particles found in this sample seems to be consistent with the findings of previous samples taken from the Orbiter lower surface. The damage site exhibited some exposure to elevated temperature in the form of tile 'glazing' and the presence of heated TPS materials.

STS-54 Organic Analysis

Added to this report are the final results of the STS-54 organic analysis, including a new type of material found in the window samples. This material appears as a adhesive/sealant similar to a Locktite. The new finding does not appear to be related to a debris problem in that no damage was associated with this residue.

The variety of residuals attributed to known sources did not seem to change significantly when compared to previous sample data (reference Figure 23).

New Findings

This sampling set provided new findings in debris residual post-flight samples. All of the new findings, which were obtained from the window samples, do not appear related to a debris damage problem. A yellow calcium or silica-rich material with a 'fused' appearance was noted. Polyvinylchloride (PVC) material with a calcium carbonate filler was also noted. A new form of Orbiter TPS, a gray insulation filler, was observed in the residual analysis. The filler is believed to have originated as a tile repair material. All of the findings are under evaluation and comparative testing to isolate exact sources.

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
56	Metallics - BSM Residue (SRB) - Solder (Launch Site) RTV, Tile, Tile coating (ORB TPS) Insulation Glass (ORB TPS) Glass fiber - 'E-glass' Paint Organics		Silica-rich tile (ORB TPS) Tile coating, RTV (ORB TPS)		
54	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite,Alpha-Quartz,Salt(Landing Site) Organics - plastic (locktite) Organics -Plastic polymer,filled plastic (PVC) Paint	Metallics - BSM Residue (SRB) Tile, Insulation Glass (ORB TPS) Calcium - Silica, Salt (Landing Site) Organics - plastic polymers Paint			
53	Metallics - BSM Residue (SRB) - Solder (Launch Site) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics - Fibrous mat'l,RTV,Grease Organics-filled rubber,plastic polymers Paint			LO2 Umbilical Door - - Closeout Mat'l (ORB TPS) - Hydrocarbon "grease-like" sub.	RH SRB Aft Skirt Damage site - - Tile, Tile coating mat'l (ORB TPS)
52	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics-Fibrous mat'l,red RTV Organics-filled rubber,plastic polymers Paint				HRSI Tile Damage Site- -Tile Mat'l and silicon carbide (ORB TPS) -Paints -Calcite,salts (Landing Site)
47	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics-Fibrous mat'l,red RTV Organics-filled rubber,plastic polymers Paint		Silica-rich Tile (ORB TPS)		
46	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite,Alpha-Quartz,Salt(Landing Site) Organics-Adhesive,Foam,red RTV Organics-filled rubber,plastic polymers Paint				Crew Hatch Window - Metallics - BSM Residue (SRB) - Alpha-Quartz, Salt (Landing Site) - RTV, Tile (ORB TPS) - Paint - Organics

Figure 23. Orbiter Post Landing Microchemical Sample Results

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
50	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Window Polish Residue (ORB) Mica, Calcium, Salt (Landing Site) Organics-Adhesive,Foam Organics-Plastic Polymers Paint		Silica-Rich Tile (ORB TPS)		Orbiter Vertical Stabilizer - Tile Coating (ORB TPS) - Structural Coating Glass "E-Glass"
49	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Calcium, Salt (Landing Site) Organics Paint	RTV, Tile (ORB TPS) Rust - BSM Residue (SRB) Muscovite, Salt (Landing Site) Organics Paint	RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Rust - BSM Residue (SRB) Calcium Mat'l,Salt (Landing Site Soil) Organics Paint		
45	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics Paint		Iron - Rich Mat'l Paint		
42	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Muscovite (Landing Site) Organics Paint		Metallics - BSM Residue (SRB) Tile, Tile Coating (ORB) Salt (Landing Site) Paint	Organics	RH Fuselage - Tile Coating (ORB)
44	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Muscovite (Landing Site) Organics Paint			Organics Silica-Magnesium Mat'l	
48	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Muscovite (Landing Site) Organics Paint			Metallics Silica - Rich Mat'l (Landing Site) Orb Umbilical C/O Mat'l (ORB) Paints	
43	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics Paint		RTV, Tile (ORB TPS) Metallics - BSM Residue (SRB) Salt (Landing Site) Organics Paint		Runway - FRSI Coating (ORB)

Figure 23. Orbiter Post L ing Microchemical Sample Results

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
40	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics Paint	Metallics - BSM Residue (SRB) RTV, Tile (ORB) Insulation Glass (ORB TPS) Ensolite Foam (RCC Prot. Covers) Organics Paint	RTV,Tile (ORB TPS)	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Organics (ORB Umb C/O) Paint	
39		Metallics - BSM Residue (SRB) RTV, Tile (ORB) Insulation Glass (ORB TPS) Ensolite Foam (RCC Prot. Covers) Organics Paint Hypalon Paint (SRB)	Tile (ORB TPS) Insulation Glass (ORB TPS)		
37	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics	Metallics - BSM Residue (SRB) RTV, Tile (ORB) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics Paint	RTV, Tile ((ORB TPS) Insulation Glass (ORB TPS) Metallics - BSM Residue (SRB) Calcite, Salt (Landing Site) Organics		
35	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics Paint -	Metallics - BSM Residue (SRB) RTV, Tile (ORB) Organics	RTV, Tile (ORB TPS) Metallic - Rust, Aluminum Welding Slag (Facility)		
38		RTV, Tile (ORB TPS) Hypalon Paint (SRB) Ensolite Foam (RCC Prot. Cover)	Tile (ORB TPS)		
41	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics	Tile (ORB TPS) Salt (Landing Site)	Tile (ORB TPS)	Calcite (Landing Site) Fluorocarbon (Viton-ORB Umb) Foam (ORB C/O)	Fwd FRSI - Silicon Mat'l (ORB TPS)
31R	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica (Landing Site) Organics Foam Insulation (ET/SRB) Paint	RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica (Landing Site) Paint		
36	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Salt (Landing Site) Paint	Rust - BSM Residue (SRB) Tile (ORB TPS) Paint Organics	RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica (Landing Site) Organics Microballoon (ET/SRB)	Rust - BSM Residue (SRB) RTV, Insulation Glass (ORB TPS) Microballoon (ET/SRB) Calcite (Landing Site) Foam, Organics (ORB Umb C/O)	

Figure 23. Orbiter Post Landing Microchemical Sample Results

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
32R	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Salt (Landing Site) Paint		Metallics - BSM Residue (SRB) Tile (ORB TPS) Carbon Fibers Titanium	Metallics - BSM Residue (SRB) RTV, Insulation Glass (ORB TPS) Phenolic Microballoon (ET/SRB) Quartz, Calcite (Landing Site) Organics	
33R	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Micaceous Mat'l, Salt (Landing Site) Window Polish Residue (ORB) Paint	Metallics - BSM Residue (SRB) Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Spar, Salt (Landing Site) Organics	RTV, Tile (ORB TPS)	Rust - BSM Residue (SRB) RTV, Insulation Glass (ORB TPS) Phenolic Microballoon (ET/SRB) Paint Organics	Crew Hatch Window - Rust - BSM Residue (SRB) - Alpha Quartz (TPS/Landing Site) - Paint - Organics
34	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Alpha-Quartz, Silicates, Salt (L/S) Window Polish Residue (ORB)	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Paint	RTV, Tile (ORB TPS) Stainless Steel Washer	RTV (ORB) Foam (ORB) Viton Rubber (ORB) Metallics - BSM Residue (SRB) Phenolic Microballoon (ET/SRB) Silicates, Calcium (Landing Site) Paint	
28R	Silicone (ORB FRCS Cover Adhesive)	Silicates (Landing Site) Paint Charred Silicone Brass Chip	RTV, Tile (ORB TPS) Clay, Sand, Quartz (Landing Site) Metallics - BSM Residue (SRB)	Sand, Silicates (Landing Site) Foam (ORB) RTV (ORB TPS) Koropon, Kapton (ORB) Metallics - BSM Residue (SRB)	OMS Pod - PVC Laminate (ORB TPS 'Shim')
30R	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Clay, Salt (Landing Site) Paint		Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Gap Filler (ORB TPS) Clay, Feldspar (Landing Site)		Upper Tile - Tile,Gap Filler (ORB TPS)
29R	RTV, Tile (ORB TPS) Metallics - BSM Residue (SRB) Ablator, Hypalon Paint (SRB)		Tile (ORB TPS) Insulation Glass (ORB TPS) Paint Muscovite - Metallics (Landing Site)	Tile (ORB TPS) Umbilical Foam (ORB) Paint Ablator, Hypalon Paint (SRB) Metallics - BSM Residue (SRB)	Upper Tile - Tile (ORB TPS)
27R	RTV, Tile (ORB TPS)	Hypalon Paint (SRB)	RTV, Tile (ORB TPS) Ablator, Hypalon Paint (SRB)		OMS Pod - Iron Fiber - PDL Foam, FRL Paint (ET) - Ablator, Hypalon Paint (SRB)
26R			RTV, Tile (ORB TPS) Paint Rust		

Sample locations vary per mission and not all locations are sampled for every mission.
( ) - identifies the most probable source for the materail.
Metallics - includes mostly Aluminum and Carbon Steel alloys

Figure 23. Orbiter Post Landing Microchemical Sample Results

10.0 POST LAUNCH ANOMALIES

Based on the debris inspections and film/video review, eight Post Launch Anomalies, including two IFA candidates, were observed on the STS-56 mission.

10.1 LAUNCH PAD/SHUTTLE LANDING FACILITY

1. A small hydrogen leak and associated ice buildup (10"x4"x3/8") was detected at the GH2 vent line elbow/flex line flange during stable replenish. Post launch disassembly of the flange revealed the old Fluorogreen gasket, which was cracked, had not been removed prior to installation of the new Fluorogold gasket. In addition, the flange bolts had not been re-torqued after the last cryogenic loading cycle.

10.2 EXTERNAL TANK

1. As many as 12 divots were present in the LH2 tank-to-intertank flange closeout on the ET -Z side. Some of the divots were 10-12 inches in diameter.

2. As many as 11 divots were present in the intertank acreage on the -Z side of the ET. Numerous divots appeared in a line and may be indicative of a spray or processing problem. Although appearing shallow in depth, several of the divots were estimated to be 24 inches in diameter. An IFA was taken against the new block of intertanks, which have shown an increasing trend in the appearance of acreage divots.

10.3 SOLID ROCKET BOOSTERS

1. Holddown Post #5 Anomaly: A plunger, spring, and associated hardware from the Debris Containment System (DCS) was found on holddown post #5 still attached to the stud. This hardware is normally contained in the DCS housing and remains with the SRB aft skirt during flight. (IFA candidate)

2. Diagonal-cutting pliers were found wedged between the HDP #4 DCS housing and the RH aft skirt forged foot web. (IFA candidate)

3. The RH frustum was missing no TPS but had 11 MSA-2 debonds over fasteners. The LH frustum had 20 MSA-2 debonds. Significant blistering of the Hypalon paint occurred in an area between the -Y and +Y axes from the BSM's to the 395 ring frame.

10.4 ORBITER

1. A thin, rectangular, dark object (possibly a tile gap filler or GSE tile shim/spacer) originated from the LH aft RCS stinger tiles (edge of the aft surface) during SSME ignition.

2. The tiles on the LH OMS pod leading edge sustained more damage than usual (at least 35 hits, of which 15 had a major dimension of 1 inch or greater). Several of the tile damage sites reached a depth ranging from 0.5 to approximately 1.25 inches. The cause of this damage is still undetermined. STS-53 was the last mission to sustain greater than average tile damage on the LH OMS pod leading edge (27 hits total; 10 hits 1-inch or greater).

Appendix A. JSC Photographic Analysis Summary

May 20, 1993

Greg Katnik
MC/TV-MSD-22
OSB Room 5203R
KSC, Florida 32899

Dear Greg,

The following Summary of Significant Events report is from the Johnson Space Center NSTS Photographic and Television Analysis Project, STS-56 Final Report, and was completed May 18, 1993. Publication numbers are LESC-30778 and JSC-25994-56. The actual document can be obtained through the LESC library/333-6594 or Christine Dailey /483-5336 of the NSTS Photographic and Television Analysis Project.

Christine Dailey 5/20/93
Christine Dailey, Project Specialist
Photo/TV Analysis Project

2.0 Summary of Significant Events Analysis

This section summarizes significant screening and image analysis activities for mission STS-56. Details of the screening and analysis can be seen in Appendices B and D. Most of the events described under Section 2.0 have been seen on previous missions. Unless stated otherwise, no follow-up actions have been requested.

The nighttime lighting conditions hindered the analysis of many of the launch views.

The debris containment system (DCS) on the LSRB holddown post M-5 was reported to have failed. The spring and plunger escaped the DCS and was impaled on the spherical bearing on the MLP. No photographic coverage of the LSRB holddown post M-5 anomaly was obtained (Camera E-12 did not run). No unidentified debris objects in the vicinity of the LSRB aft skirt were observed.

KSC reported a hydrogen leak and ice formation near the GH2 vent line elbow/flex line flange. Nothing unusual in this area was observed on the films.

2.1 Debris

The only debris observed to strike the vehicle (near the sill of the Orbiter umbilical well) was ice/frost from the ET/Orbiter LH2 umbilical during SSME startup. It is also possible that ice/frost debris from the forward end of the shuttle launch vehicle (SLV) struck the Orbiter fuselage tiles at liftoff. No damage to the SLV was observed on any of the launch and landing films and videos. The multiple pieces of debris seen falling aft of the SLV at liftoff, throughout the roll maneuver, and beyond on the launch tracking views was typical to previous missions. Most of the debris sightings were probably reaction control system (RCS) paper, ice/frost from the Orbiter umbilicals or chunks of propellant from the solid rocket boosters. Some of the debris may have been from the intertank TPS of the external tank. Unless stated otherwise, no follow up action has been requested.

2.0 Summary of Significant Events Analysis

2.1.1 Debris near the Time of SSME Ignition

2.1.1.1 Debris Strike to Tiles near Umbilical Well Sill
(Cameras OTV-109, OTV-163, E-6, E-31)

At least one piece of white debris, appeared to strike the underside of the Orbiter near the LH2 umbilical well during SSME startup (05:28:57.575 UTC). The white debris appeared to be frost/ice from the ET/Orbiter LH2 umbilical. No damage to the vehicle was observed.

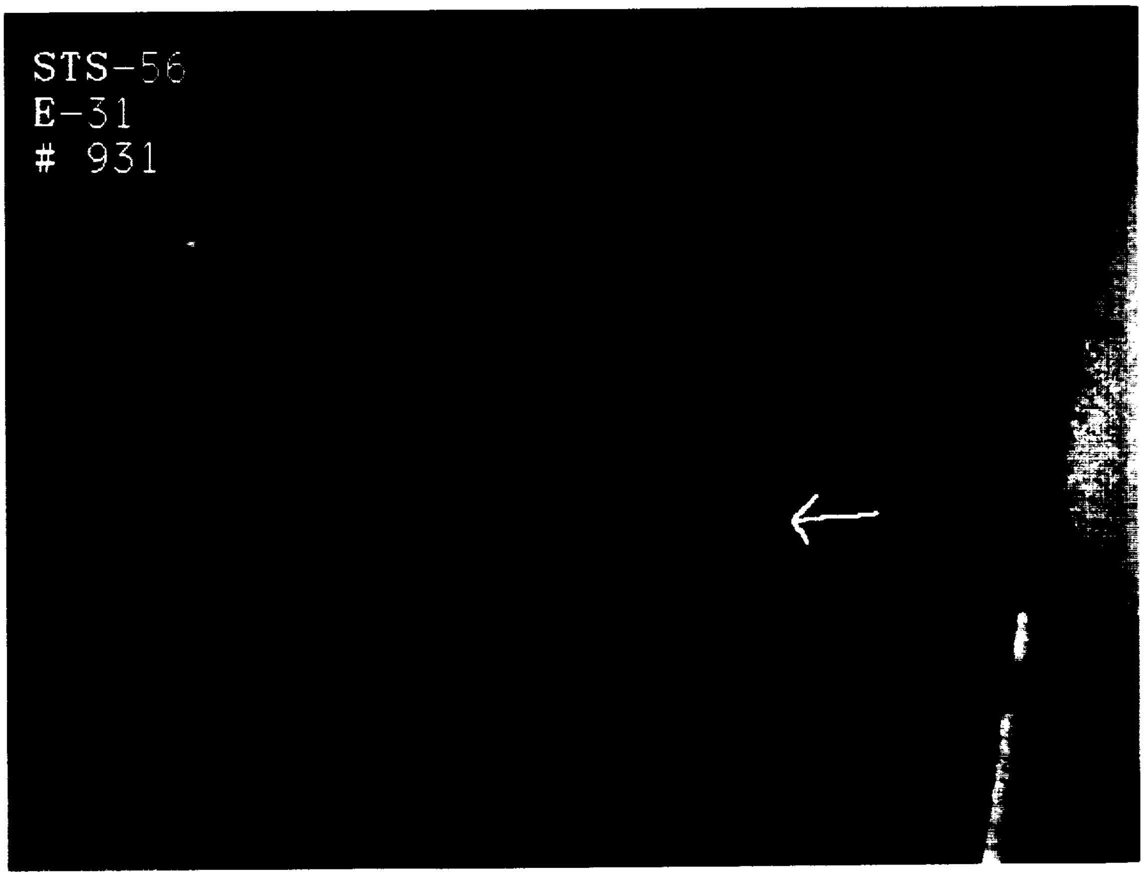


Figure 2.1.1.1 Debris Strike to the Lower Side of the Orbiter

The arrow points to a white piece of debris as it struck below the LH2 umbilical well sill during SSME ignition.

ORIGINAL PAGE
COLOR PHOTOGRAPH

2.1.1.2 LH2 and LO2 Umbilical Disconnect Debris

(Cameras OTV-109, OTV-149, OTV-150, OTV-151, OTV-154, OTV-163, OTV-170, OTV-171, E-2, E-3, E-5, E-6, E-17, E-18, E-19, E-20, E-31, E-34, E-40, E-52, E-62, E-76, E-77)

The usual amount of ice debris from the LO2 and LH2 TSM T-0 umbilicals as well as the ET/Orbiter umbilicals were noted on many of the MLP camera films and videos. Multiple pieces of ice and/or liquid were seen falling from the flange of the LH2 17 inch ET/Orbiter umbilical line. A single dark piece of debris was seen near the LH2 T-0 TSM umbilical at SSME startup.

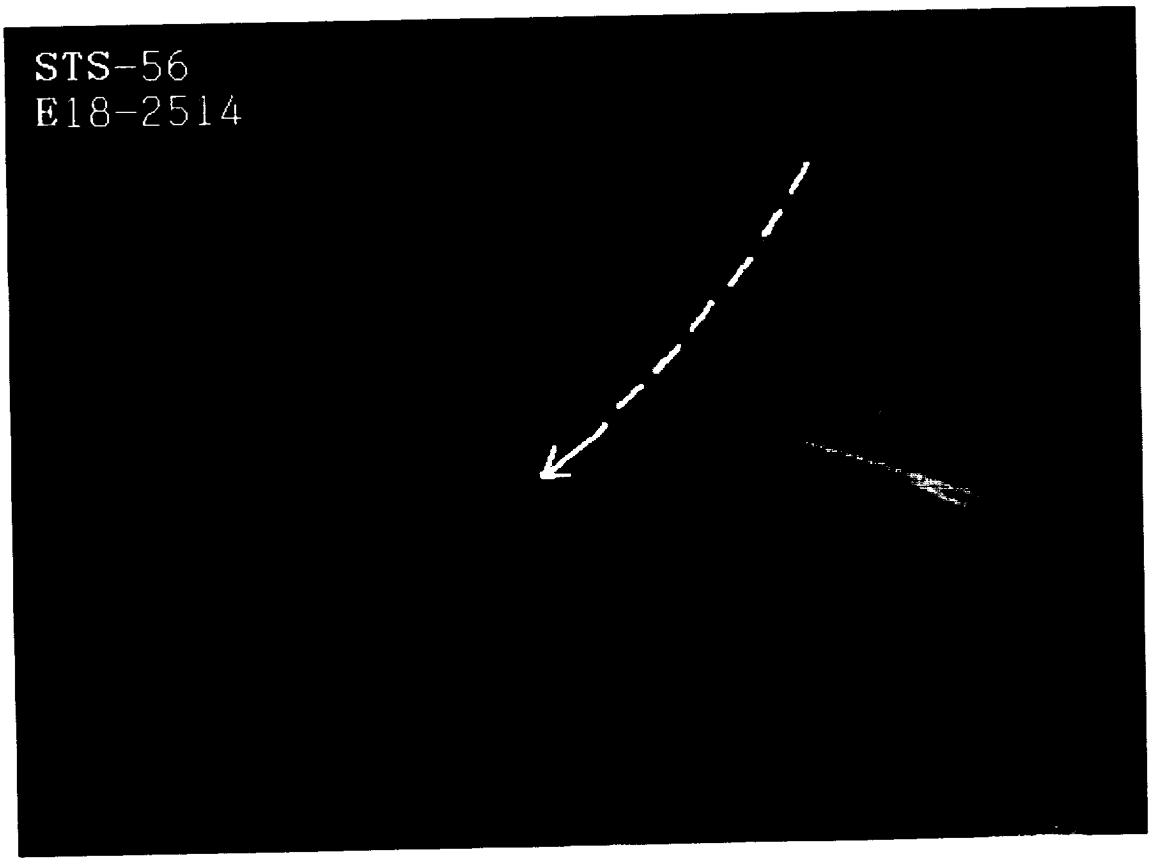


Figure 2.1.1.2 Dark Debris from LH2 TSM Umbilical

A single dark piece of debris (arrow), possibly a piece of tape, originated from the LH2 T-0 TSM umbilical and fell aft at SSME startup (05:28:56.938 UTC).

2.1.1.3 Debris from Left Aft RCS Stinger Area
(Camera E-20)

A thin, rectangular object, dark on one side and light on the other, originated from the left aft RCS stinger area and fell aft during SSME ignition.

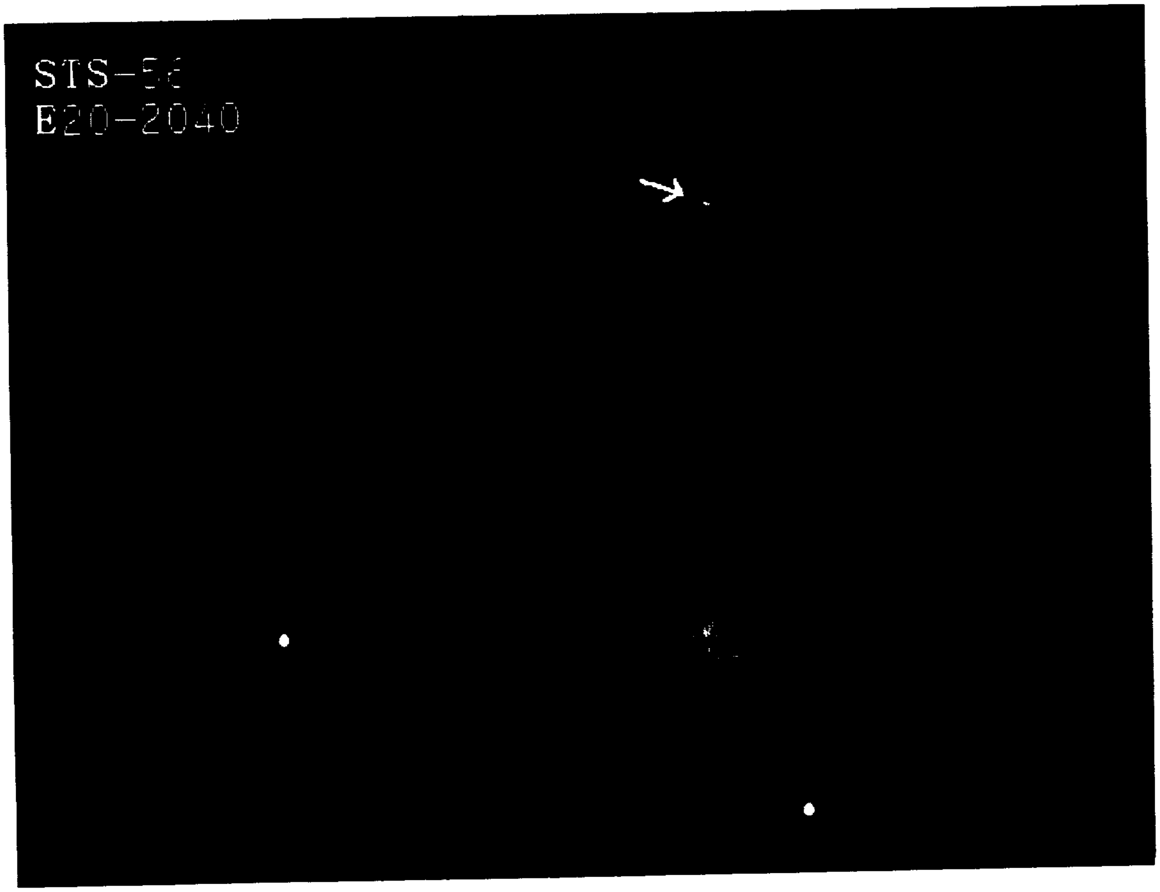


Figure 2.1.1.3 Debris from Left Aft RCS Stinger Area

KSC stated that the debris from the left aft RCS stinger area (arrow) was possibly a tile gap filler or tile shim.

2.1.1.4 Dark Debris Below SSME #1
(Camera E-3)

A single small dark piece of debris was seen falling aft of SSME #1 at SSME startup (T-3.548 seconds). The origin of the debris could not be determined.

2.1.2 Debris near the Time of SRB Ignition

2.1.2.1 Debris North of MLP after Liftoff *(Task #13)* *(Cameras KTV-7B, KTV-21B, E-62, E-222, E-224)*

Figure 2.1.2.1 Debris North of MLP after Liftoff

Multiple pieces (at least five) of debris were seen above the SRB exhaust plume from approximately 0.9 seconds MET until 2.3 seconds MET. The objects were not seen to strike the vehicle. The debris appeared to be well north and east of the MLP and initially moved up and then down as the vehicle lifted off.

An attempt was made to use a Cartesian phototheodolite program to estimate the 3D position of the debris. The phototheodolite method was unsuccessful in producing acceptable results because there was no way to tell if the same debris was being seen by each camera and the location of the camera positions in Orbiter coordinates was not very accurate.

Instead of using a phototheodolite method to obtain the 3D positions of the debris, a single camera solution using KTV-7B and E-62 separately was used. KTV-7B is located almost due east of the pad. The distance north of the MLP and the height of the debris can be estimated well from this view. Using the ET diameter for scale and assuming that the debris is at the same distance as the ET, the distance of three pieces of debris from the MLP were 185 ft., 176 ft., and 201 ft. while their heights were 103 ft., 94 ft., and 93 ft.

respectively. Since the debris was closer to the camera than the ET (this was confirmed from the KTV-21B and the E-222 views that showed the debris to the east of the MLP) the distance estimates are maximum distances.

Using the approximated distances of the debris from the MLP calculated from camera KTV-7B, the size and velocity of the debris was estimated using data from camera E-62. Camera E-62, located on the perimeter southeast of the MLP, showed that the debris initially moved up and then fell back as the vehicle lifted off. The size and velocity of the debris that appeared to attain the highest altitude was measured. The size and velocity represent a maximum since the KTV-7B estimates of debris distance from the MLP were simply added to the distance of the camera from the MLP. The maximum diameter of the debris was found to be approximately 10.6 inches and the maximum velocity was found to be approximately 28.5 feet per second.

From this analysis it was not possible to tell if the debris was associated with the vehicle (e.g.. SRB flame duct debris) or unassociated objects such as birds.

2.1.2.2 SRB Flame Duct Debris *(Task #7)* *(Cameras E-7, E-8, E-9, E-11, E-13, E-14, E-16, E-62, E-224)*

No debris from the SRB flame duct was identified that would require a follow-up velocity determination. The debris seen north of the MLP on cameras E-62, E-222, KTV-7B and KTV-21B could possibly have been associated with the flame duct but this could not be confirmed. See section 2.1.2.1 and in Appendix D, Task #13 for more information on this debris.

2.1.2.3 Debris from LO2 TSM Carrier Plate
(Camera E-19)

Figure 2.1.2.3 Debris from LO2 TSM Carrier Plate

A single light colored piece of debris appeared to originate between the LO2 TSM carrier plate and the Orbiter and fall aft at liftoff (0.335 seconds MET).

2.1.2.4 Debris in Front of RSRB
(Camera E-9)

Figure 2.1.2.4 Debris in Front of RSRB

A thin flat rectangular piece of debris (light on one side and dark on the other) fell through the field of view from left to right in front of the right SRB at liftoff (0.562 seconds MET). The object did not appear to strike the vehicle.

2.1.2.5 Dark Debris in Front of Left Wing
(Camera E-41)

A single piece of dark debris was seen to travel in front of the left wing of the Orbiter at liftoff. The origin of the debris was not determined. The debris did not appear to strike the vehicle.

2.1.3 Debris after Liftoff

Multiple pieces of debris were seen falling aft of the SLV from liftoff through ascent on the launch tracking views. Debris falling aft of the SLV after liftoff has been seen on films and videos from all previous missions. Most of this type of debris has been attributed to ice from the ET/Orbiter umbilicals or RCS paper. Some of the debris may have been from the intertank TPS of the external tank. This assumption is based on the appearance of the external tank as recorded on the handheld photography taken by the astronauts after main engine cut off

(MECO). See section 2.3.6 DTO-312 Onboard Handheld Camera ET Analysis. None of the debris seen after liftoff appeared to strike the vehicle.

2.1.3.1 Debris Near ET Forward Bipod

(Cameras OTV-161, E-34)

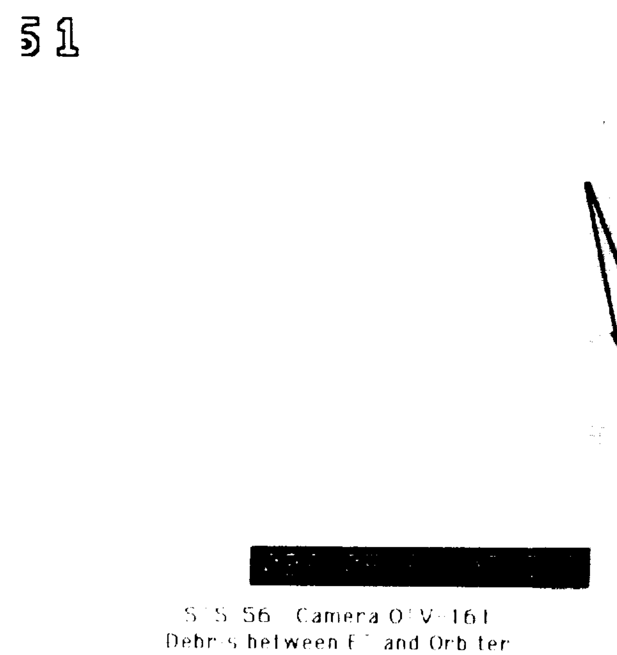


Figure 2.1.3.1 Debris Between Orbiter and ET

Several small pieces of white debris were seen falling aft of the ET forward bipod between the Orbiter and the ET at liftoff (3.38 seconds MET). Some of the debris may have struck the vehicle, but no damage was observed.

2.1.3.2 Baggie Material Debris

(Camera E-220)

Orange colored debris, probably umbilical purge barrier (baggie) material, was seen falling aft of the ET/Orbiter umbilicals at 22.85 seconds MET.

2.1.3.3 Debris Near the Orbiter

(Cameras ET-207, ET-208, E-54, E-57, E-62, E-207, E-212, E- 213, E-220, E-223, E-224)

The following are examples of some of the debris items seen after liftoff that were first seen near the Orbiter. Most of this type of debris can be attributed to RCS paper and ice from the ET/Orbiter umbilicals: At 3.94 seconds MET, a small light colored piece of debris (origin undetermined) fell aft of the left outboard elevon at tower clear (E-223). At 5.03 seconds MET, a single light colored piece of debris first seen at the base of the vertical stabilizers fell aft into the SSME exhaust plume (E-224). A light colored piece of debris was seen falling aft along the Orbiter right wing at 17.846 seconds MET (E-54). The debris was first seen coming from behind the right OMS pod. At 33.06 seconds MET, a second light colored piece of debris fell along the Orbiter left wing and aft into the

SLV exhaust plume. At 36.58 seconds MET, light colored debris was seen falling aft from near the vertical stabilizer (E-212, E-223). At 38.06 seconds MET, multiple pieces of orange colored debris were seen near the Orbiter vertical stabilizer falling aft toward the SLV exhaust plume (E-207). At 39.17 seconds MET apparent forward RCS paper debris was noted on film E-220. A light colored piece of debris first seen near the left OMS pod fell aft of the base of the vertical stabilizer at 55.82 seconds MET. This piece of debris appeared larger than the typical RCS paper debris (Camera E-220).

2.1.3.4 Debris Causing Orange Streak in SSME Plume

(Cameras E-205, E-223)

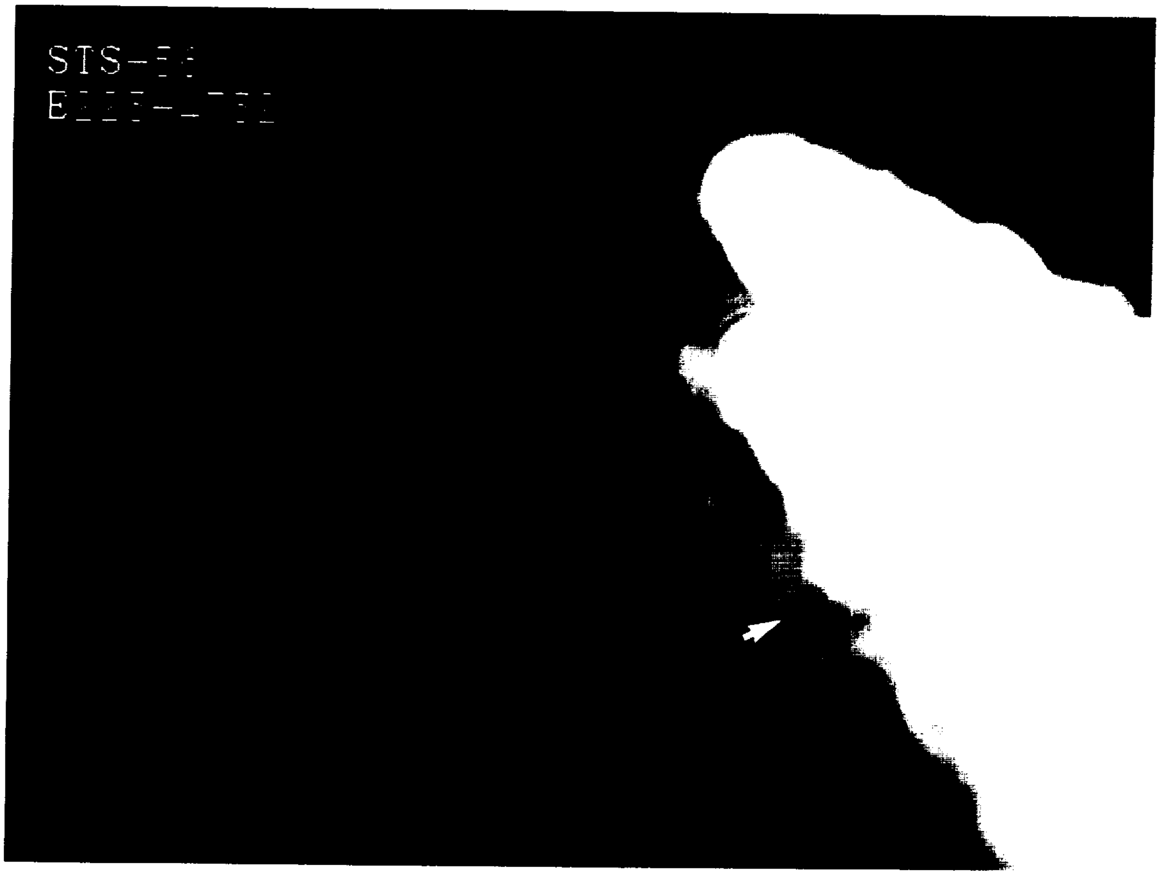


Figure 2.1.3.4 Debris Causing Orange Streak in SSME Plume

A single light colored piece of debris fell aft into the SSME plume and caused a bright orange streak at approximately 45.1 seconds MET. The streak was seen for 8 frames or 0.083 seconds.

2.1.3.5 Debris Near SRB Exhaust Plume During Ascent

(Cameras ET-204, ET-207, ET-208, ET-212, KTV-13, E-57, E-59, E-205, E-207, E-208, E-212, E-218, E-220, E-223, E-224)

A large amount of debris was seen coming from above and below the SRB exhaust plume between the roll maneuver and SRB separation. Some of the debris was seen to come in large clusters. None of the debris was seen to strike the launch vehicle.

2.2 MLP Events

2.2.1 Discoloration of the R2D RCS Cover

(Cameras OTV-170, OTV-171, E-2, E-19)

Figure 2.2.1 Discoloration of the R2D RCS Cover

A discoloration of the R2D RCS cover on the right RCS stinger was noted before SSME startup.

2.2.2 Orange Vapor (Possibly Free-Burning Hydrogen)
(Cameras OTV-163, OTV-170, OTV-171, E-4. E-16, E-30, E-36))

Orange vapor, possibly free burning hydrogen, was noted beneath the body flap and above the rims of SSME #1, SSME #2, and SSME #3 at SSME startup (T - 4.94 seconds on the camera E-4 view). Since free burning hydrogen is essentially colorless, engineers who reviewed films after the STS-38 mission believed that the orange cloud occurred due to impurities in the vapor. Similar events have been seen on past missions.

Figure 2.2.2 Orange Vapor (Possibly Free-Burning Hydrogen) Noted under the Body Flap

Orange vapor is visible beneath the body flap in the camera OTV-163 at SSME ignition.

2.2.3 Vapor near Right OMS Nozzle
(Camera E-2)

A white vapor was noted between the right OMS nozzle and the right RCS stinger at SSME startup (T-1.7 seconds).

2.2.4 Vapor near Aft ET/SRB Attach Point
(Camera E-2)

A white vapor was noted near the aft ET/SRB attach point at liftoff.

2.2.5 Possible TPS Erosion
(Cameras E-18, E-20)

Possible TPS erosion was noted on the left inboard elevon and at the base of the left RCS stinger prior to liftoff. Slight TPS erosion was also seen on the base of the left OMS pod and between the SSME's. Minor TPS erosion has been seen on nearly all previous

missions. This occurrence is believed to result from the vibrations caused by SSME ignition.

2.2.6 Orange Flashes and Flares in SSME Exhaust Plume *(Cameras OTV-170, E-5, E-50, E-54, E-207, E-212, E-213, E-218, E-223)*

Several orange flashes were noted in the SSME #3 plume at liftoff (05:29:00.612 UTC).

Multiple orange flares were noted in the SSME exhaust plumes between 13 and 47 seconds MET. Several of the flares were identified to be in the SSME #1 exhaust plume. Flares during this time period have been seen on several earlier missions. Flares on earlier missions have been attributed to RCS paper burning up in the SSME plume.

2.2.7 Discoloration of RSRB Holddown Post M-4 Foot *(Camera E-7)*

A discoloration was noted on the outboard edge of the RSRB foot of holddown post M-4 at liftoff.

2.3 Ascent Events

2.3.1 Loose Thermal Curtain Tape on RSRB Aft Skirt

(Cameras E-25, E-57, E-220, E-222, E-223)

Figure 2.3.1 Loose Tape on RSRB Thermal Curtain

A loose thermal curtain tape was noted on the aft skirt of the RSRB during liftoff prior to the roll maneuver. This event has now been seen on five missions since reflight.

2.3.2 Light Colored Vapor above SSME #1

(Cameras E-207, E-212)

Figure 2.3.2 Light Colored Vapor above SSME # 1 after Liftoff

A light colored vapor was noted above SSME #1 and traveled into the SSME plume after the roll maneuver at 58.84 seconds MET. The vapor was in view for four frames or 0.062 seconds.

2.3.3 Body Flap Motion *(Task #4)*

2.3.3.1 Body Flap Motion seen at SSME Ignition

(Cameras E-17, E-18)

As part of an ongoing study, flap deflection was measured just aft after SSME ignition on Cameras E-17 and E-18. Results from STS-56 as well as other OV-102 and OV-103 missions have been summarized in the LESC document "Photographic Analysis of the Space Shuttle Body Flap Motion seen at SSME Ignition" (LESC-30803).

The STS-56 data indicated a maximum deflection of 0.6 inches on the starboard side and 0.7 inches on the port side. A power spectrum analysis was performed over the full 310 frame sequence (~0.775 seconds). The analysis indicated the presence of global rotation, torsion and the second bending modes on the port side; and all of these plus local rotation and the first bending moment on the starboard side.

2.3.3.2 Body Flap Motion seen during Ascent *(Cameras E-207, E-212, E-223)*

Films from Camera E-207, E-212 and E-223 were re-screened for a subjective measure of the amount of body flap motion visible. A preliminary analysis indicated the presence of significant body flap motion seen on Camera E-207.

Three points were digitized on each frame between 2830 and 2930 (from 47.894 seconds MET through 49.484 seconds MET). These points consisted of the starboard and port trailing edges of the flap and a control point located at the top aft corner of the speed brake. Measurements were made by three different analysts as a statistical check. The maximum deflection of the starboard corner of the trailing edge of the flap was found to be 5.58 inches (+/-2.84 inches). The maximum deflection on the port trailing edge was measured at 5.83 inches (+/-2.74 inches). A power spectrum analysis was performed on the sequence of frames (2860-2900) where the maximum deflection was observed. This analysis indicated the presence of a strong global rotation component. Graphs and calculations are shown in Appendix D.

2.3.4 Elevon Position after Liftoff *(Task #11)* *(Camera E-212)*

The mission evaluation room (MER) manager reported that during ascent at approximately 65 seconds mission elapsed time (MET), small left and right outboard elevon deflections along with outboard elevon primary differential oscillations were observed. No elevon load relief had been commanded.

The difference between the STS-56 Orbiter left wing inboard and outboard elevon positions was investigated using film from the long range tracking cameras. The position of the left inboard and outboard elevons seen on STS-56 was also compared to the elevon positions seen on other selected missions. Film from camera E-212 from STS-39 and STS-48 were reviewed to compare the relative positions of the left wing elevons. These missions were chosen because they were both night launches and were at 57 degree inclinations.

STS-39 launched at nearly dawn. Therefore, the lighting permitted good visibility of the SLV on the camera E-212 film. There was an obvious difference in the left wing inboard and outboard elevon positions on the STS-39 film. The elevon positions on STS-39 were almost exactly the same as that seen on STS-56.

The E-212 film from STS-48 was dark and slightly out of focus. Aside from this, the inboard and outboard left elevon positions on STS-48 appeared similar to that of STS- 56. The visual analysis findings on the elevon positions were reported to the mission evaluation room manager prior to landing.

2.3.5 Recirculation *(Task #1)* *(Camera E-205)*

The recirculation or expansion of burning gases at the aft end of the SLV prior to SRB separation has been seen on nearly all previous missions. For STS-56, the start of recirculation was observed at about 93 seconds MET and the end was noted at approximately 111 seconds MET on Camera E-205. Due to the night time lighting conditions and the launch inclination angle, this was the only camera that provided a good view of recirculation.

2.0 Summary of Significant Events Analysis

See Appendix D, Task #1 for a summary of recirculation start and stop times for all missions since reflight.

2.3.6 DTO-312 Onboard Handheld Camera ET Analysis
(Task #6)
(Magazines 02 and 03))

STS-56 crew performed DTO-0312 acquiring 72 views of the external tank (ET) from two rolls of 35 mm film. Apparent damage to the external tank thermal protection system (TPS) on the intertank acreage was observed. The markings or divots seen on the photography resulted in the declaration of a inflight anomaly (IFA number STS-56-T-001).

The photographs were taken by Astronaut Ellen Ochoa using Nikon F4 camera with a 300 mm lens (Method 3). The analysis results were reported to the Mission Evaluation Room (MER) Manager and to the standard distribution.

The entire ET was photographed except the side toward the Orbiter (as the vehicle sits on the pad, or the +Z axis). The pictures were acquired several minutes later than usual because the night launch increased the time before the tank entered daylight.

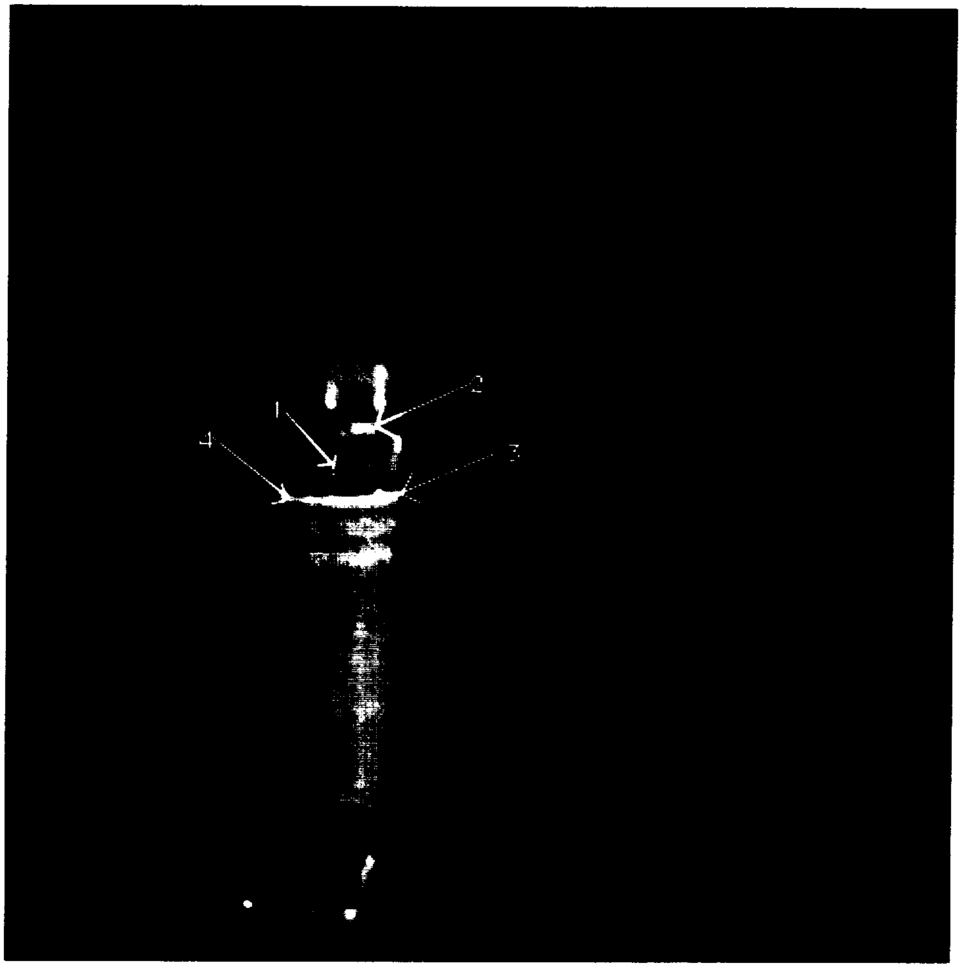


Figure 2.3.6 Divots on ET

Six or more light colored marks or divots were visible on the intertank TPS on the -Z or far side of the ET. These marks ranged between 18 and 26 inches (Figure 2.3.6 arrows 1 and 2). This view was taken while the ET was 2.30 km from the Orbiter at approximately eleven minutes after ET separation. The light colored mark visible on the ET LH2 tank/aft dome interface is the RSRB/ET aft attach. The TPS on the ET nose and aft dome appeared charred as usual. The booster separation motor (BSM) burn scars on the LO2 tank appeared typical to previous missions.

Approximately five marks or divots are visible on the LH2/Intertank closeout flange on the -Y axis of the ET in the above view. The divots in this area ranged between 16 and 24 inches (Figure 2.3.6 arrows 3 and 4). Bright marks are visible on the aft ET/Orbiter attach bracing. These bright marks have been determined to be reflections of sunlight off normal protuberances on the attach bracing.

No tumble analysis was performed since the ET was not observed to rotate at least 90 degrees. Detailed notes for all the photographic screening are located in Appendix D Task #6.

2.0 Summary of Significant Events Analysis

2.4 On Orbit

2.4.1 Debris Seen During Spartan Capture *(Task #12)*

Figure 2.4.1 Debris Seen During Spartan Capture

The white debris object annotated above was seen on video during the Spartan capture. Measurements of the size and velocity of this object were made and provided to the mission evaluation manager. The diameter of the RMS end effector was used for scale in order to determine the size of the object. The diameter of the RMS is 13.6 inches without the thermal blanket material. The object was seen to pass in front of the RMS arm. Therefore a maximum size estimate of the object was made assuming the debris to be at the same distance as the arm. The dimension of the object was determined to be approximately 2 x 3 inches. The diameter of the RMS in the image was probably slightly greater than 13.6 inches because the thermal blanket material was attached. This would make the maximum size of the debris object slightly larger.

The debris distance in inches was plotted versus time and a regression line was fit to the data. The slope of the regression line was used as the velocity. The velocity of the debris object was found to be approximately 1.15 feet per second. This velocity represents a maximum velocity since the scale was determined using an object that is further from the camera than the debris.

2.5 Landing Events

2.5.1 Landing Sink Rate Analysis *(Task #3)*

2.5.1.1 Landing Sink Rate Analysis Using Film *(Cameras EL-9, EL-12)*

Camera EL-9 was used to determine the film sink rate of the main gear. The analysis showed that the main gear sink rate was 3.96 feet per second. Data was gathered approximately 1 second prior to landing through touchdown or approximately 100 frames. The points digitized were right main gear, left main gear and top of the runway below both main gear. For main gear sink rate, the scale was found using the distance between the main landing gear struts. An assumption was made that the plane of the camera was parallel with the Orbiter's y-z plane. The y distance between the average position of the main gear and the runway was then multiplied by the scale to find the height of the main gear above the runway. The height of the vehicle above the runway was plotted with respect to time. A linear least squares line was fitted to the points. The slope of the line equals to the main gear sink rate.

Nose gear touchdown occurred approximately 15 seconds after main gear touchdown. This rate was determined to be 3.28 feet per second. Camera EL-12 was used to determine the sink rate of the nose gear. Scalar information was determined by a system of equations which took into account the orientation of the camera relative to the Orbiter. Data was gathered approximately 2 seconds prior to landing through touchdown at a rate of 51 frames per second which is the temporal resolution of the film. The equations were solved for each observation which took into account the change in perspective as well as increase in size. The distance between the bottom of the nose gear and the runway was computed and a linear least squares line was fit to the data. The slope of the vertical distance versus time data is the actual sink rate.

Graphs depicting the above data can be seen in Appendix D, Task #3

2.5.1.2 Landing Sink Rate Analysis Using Video *(Cameras SLF-South LSOC, KTV-33L)*

Sink rate was calculated for the main gear of the vehicle using a single camera solution. The analysis showed that the main gear sink rate was 3.83 feet per second. SLF-South LSOC was used to determine the video sink rate of the main gear. Data was gathered approximately 1 second prior to landing through touchdown at a rate of 30 frames per second. The points digitized were right main gear, left main gear and top of the runway. For main gear sink rate, the scale was found using the distance between the main landing gear struts. An assumption was made that the plane of the camera was parallel with the Orbiter's y-z plane. The y distance between the average position of the main gear and the runway was then multiplied by the scale to find the height of the main gear above the runway. These heights were then regressed with respect to time. The slope of the regression line was equal to the main gear sink rate.

Nose gear touchdown occurred approximately 15 seconds after main gear touchdown. Camera TV-33 was used to determine the sink rate of the nose gear. Scalar information was determined by a system of equations which took into account the orientation of the camera relative to the Orbiter. Data was gathered approximately 1 second prior to landing through touchdown at a rate of 30 frames per second, the temporal resolution of the video. The equations were solved for each observation which took into account the change in perspective as well as increase in size. The distance between the bottom of the nose gear and the runway was computed and a linear regression was applied on this normalized vertical distance versus time data to find the actual sink rate. This rate was determined to be 3.44 feet per second. See Appendix D, Task #3 for details.

2.5.2 Debris from Nose Wheel Area

(Cameras SLF East, SLF West, and SLF Infrared)

Several pieces of debris appeared to fall from the nose wheel area at nose gear door opening on the above infrared views. Additional debris may have fallen from the main gear area. The debris traveled along the underside of the Orbiter and toward the left wing. KSC reported that the warm objects falling away from the nose landing gear area were gap fillers. The gap fillers were inserted into open spaces after the closure of the landing gear door(s) to prevent heat intrusion during reentry.

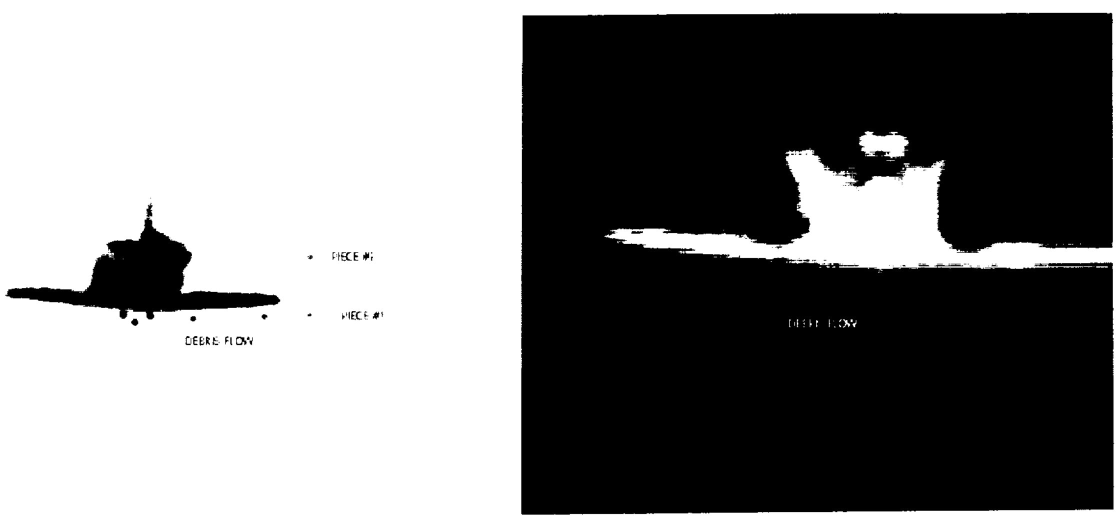


Figure 2.5.2 Debris from Nose Wheel Door Area Before Landing

The red dots on the views above trace the path of the debris seen at the time the landing gear doors were opened. The view on the left is negative infrared taken from the west side of runway 33. The view from the right is a positive infrared taken from the east side of runway 33.

2.0 Summary of Significant Events Analysis

2.5.3 Drag Chute Performance *(Task #9)* *(Cameras EL-7, EL-7A, EL-10, EL-9, EL-9A, EL-12, EL-15)*

The landing of Discovery at the end of mission STS-56 marked the seventh deployment of the Orbiter drag chute. All components of the drag chute appeared to deploy as expected. A 'quick-look' analysis of the drag chute heading angles was performed using video from video camera SLF SOUTH TBC. Standard analysis of the drag chute angles as a function of time was performed using the views from the film cameras EL-9 and EL-7. This analysis is used to support the improvement of the aerodynamic math models currently in use. An extra task on this mission was to perform comparative drag chute diameter measurements between this mission and previous missions. The drag chute diameter was measured to be approximately 25.6 feet on this mission. The diameter was measured on several previous missions and found to be approximately 28.2 feet. The smaller diameter was an intentional technique intended to aid in stabilizing the dynamic behavior of the drag chute. The chute behavior did appear to be significantly more stable than on previous missions. The maximum chute deflection was approximately 4.2 degrees and the average peak to peak deflection was approximately 3 degrees, significantly less than on previous missions.

Graphical and tabular representations of the results of this analysis may be found in Appendix D, Task #9.

2.5.4 Post Landing Video Inspection

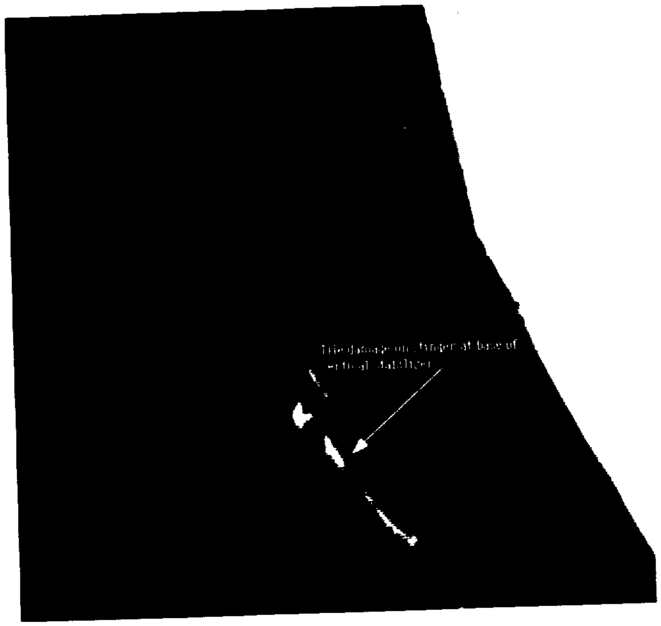


Figure 2.5.4 Tile Damage to Vertical Stabilizer Stinger

Several tiles were seen to be damaged on the right aft edge of the vertical stabilizer stinger during the screening of the post landing video inspection views.

Other items noted during the screening of the post-landing inspection video views were:

Fabric on the leading edge of the nose wheel doors appeared to be torn or missing.

Portions of the fabric in the nose wheel well appeared discolored.

Missing tile surface material on the upper edge of the right nose gear door was visible.

Pieces of umbilical purge barrier (baggie material) and loose stripping were visible in the close-up views of the umbilicals.

2.6 Other Normal Events

Other normal events observed included: frost buildup on SSME vent nozzles, elevon motion noted at SSME startup and liftoff, frost on ET GOX vent louvers, ice /frost falling from GUCP during disconnect, ET twang, ropes on MLP at liftoff, vapor from the rudder speed brake drain vent, RCS paper debris at SSME startup and after liftoff, vapor from the ET aft dome and SRB stiffener rings after liftoff, flashes in the SSME plume during startup, minor pad debris in SLV exhaust plume after liftoff, charring of the ET aft dome and ET aft dome outgassing after liftoff, white flashes in the SSME exhaust plume after the roll maneuver, expansion waves, linear optical distortions, and plume brightening.

ORIGINAL PAGE
COLOR PHOTOGRAPH

Appendix B. MSFC Photographic Analysis Summary

National Aeronautics and
Space Administration

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NASA

ply to Attn of: EP53 (93-35)

TO: Distribution

FROM: EP53/Tom Rieckhoff

SUBJECT: Engineering Photographic Analysis Report for STS-56

Enclosed is the Engineering Photographic Analysis Report for the Space Shuttle Mission STS-56. For additional copies, or for further information concerning this report, contact Tom Rieckhoff at 544-7677, or Jeff Hixson, Rockwell at 544-7121.

Tom Rieckhoff

Tom Rieckhoff

Enclosure

ENGINEERING PHOTOGRAPHIC ANALYSIS REPORT

STS-56

FINAL

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STS-56 ENGINEERING PHOTOGRAPHIC ANALYSIS REPORT

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APPENDIX C - INDIVIDUAL VIDEO CAMERA ASSESSMENT *

* Photographs in the individual camera assessments are representative photographs and are not necessarily photographs taken from this particular launch.

April 23, 1993

I. INTRODUCTION

Space Shuttle Mission STS-56, the sixteenth flight of the Orbiter Discovery was conducted April 8, 1993 at approximately 12:32 A.M. Central Daylight Time from Launch Complex 39B (LC-39B), Kennedy Space Center (KSC), Florida. Extensive photographic and video coverage was provided and has been evaluated to determine proper operation of the ground and flight hardware. Cameras (video and cine) providing this coverage are located on the fixed service structure (FSS), mobile launch platform (MLP), LC-39B perimeter sites, onboard, and uprange and downrange tracking sites.

II. ENGINEERING ANALYSIS OBJECTIVES:

The planned engineering photographic and video analysis objectives for STS-56 included, but were not limited to the following:

a. Overall facility and Shuttle vehicle coverage for anomaly detection
b. Verification of cameras, lighting and timing systems
c. Determination of SRB PIC firing time and SRB separation time
d. Verification of Thermal Protection System (TPS) integrity
e. Correct operation of the following:
   1. Holddown post blast covers
   2. SSME ignition
   3. LH2 and LO2 17" disconnects
   4. GH2 umbilical
   5. TSM carrier plate umbilicals
   6. Free hydrogen ignitors
   7. Vehicle clearances
   8. GH2 vent line retraction and latch back
   9. Vehicle motion

There was one special test objective for this mission:

a. DTO-0312, ET photography after separation

III. CAMERA COVERAGE ASSESSMENT:

Film was received from forty-eight of fifty-one requested cameras as well as video from all twenty-four requested cameras. The following table illustrates the camera data received at MSFC for STS-56.

CAMERA DATA RECEIVED FOR STS-56

	16mm	35mm	Video
MLP	19	0	4
FSS	7	0	3
Perimeter	3	3	6
Tracking	0	15	11
Onboard	0	1	0
Totals	29	19	24

A detailed individual motion picture camera assessment is provided as Appendix B. Appendix C contains detailed assessments of the video products received at MSFC.

a. Ground Camera Coverage:

Photographic coverage of STS-56 was considered good. Coverage was degraded due to the low light levels at night. The northern tracking cameras acquited limited data due to the cloud coverage. The film from cameras E-12, E-15, and E-26 broke on start. These malfunctions may have been due to the extended nitrogen purge. This extended purge resulted from the earlier (48 hours) launch scrub. Camera E-64 experencied a mechancial failure (broken belt) resulting in no data.

b. Onboard Camera Assessment:

The astronauts carried two 35mm hand-held cameras to record film for evaluating the ET TPS integrity after ET separation. No on-board SRB cameras were flown due to the night time launch.

IV. ANOMALIES/OBSERVATIONS:

a. General Observations:

While viewing the film, several events were noted which occur on most missions. These included: pad debris rising and falling as the vehicle lifts off; debris induced streaks in the SSME plume; ice falling from the 17" disconnects and umbilicals; and debris particles falling aft of the vehicle during ascent, which consist of RCS motor covers, hydrogen fire detectors and purge barrier material.

A loose piece of thermal curtain tape was noted outboard the right SRB at liftoff. Body flap and inboard right elevon motions were noted during ascent. Several large pieces of debris were observed north of the MLP during SRM ignition. It is believed that this debris originated from the SRM flame duct.

A light discoloration on the SRB holddown post M-4 was noted during liftoff. This discoloration is shown in figure 1. A black mark was observed on the right SRB forward skirt below the access door prior to liftoff. This type of mark was previously observed on STS-54.

b. SRM Slag:

Copious amounts of slag were observed exiting the SRM plumes during ascent. These observations are not considered anomalous because of the increase in image contrast resulting from the night sky conditions. One large piece of "slag" entered the SSME plume creating a large orange flare. This event is shown in figure 2 from camera E-222 at T+43.7 seconds.

Due to the SRM chamber pressure anomaly on STS-54, a study was conducted to determine if there is a correlation between amount of slag observed and chamber pressure increases. Film from nighttime launches and tests were chosen because the contrast between the dark sky and the bright slag makes these particles more visible. For the launches, cameras E-207 and E-208 were used for STS-33, 35, 36, 38, 48, 49, and 56. The two nighttime tests were TEM-9 and DM-9. The number of particles expelled from the plume and the time of occurrencs were noted. These data are presented in figures 3-16. Camera E-208 on STS-33 provided no data due to poor image quality. Camera E-208 on STS-35 was not available.

c. ET TPS Divots

Seventy-two frames of the ET after separation were received and reviewed. At least fifteen divots were noted on the LH2 intertank TPS acreage and on the LH2 intertank scarf joint on the -Z side of the ET. Figure 17 is a frame of film taken from the 35mm on-board camera showing these divots.

V. ENGINEERING DATA RESULTS:

a. T-Zero Times:

T-Zero times are determined from cameras which view the SRB holddown posts numbers M-1, M-2, M-5 and M-6. These cameras record the explosive bolt combustion products.

POST	CAMERA POSITION	TIME (UTC)
M-1	E-9	098:05:28:59.995
M-2	E-8	no data
M-5	E-12	no data
M-6	E-13	098:05:28:59.996

b. ET Tip Deflection:

Maximum ET tip deflection for this mission was determined to be approximately 32.4 inches. Figure 18 is a data plot showing the measured motion of the ET tip in both the horizontal and vertical directions. These data were derived from camera OTV-161.

c. SRB Separation Time:

SRB separation time for STS-56 was determined to be 098:05:31:05.89 UTC taken from camera E-208.

Figure 1 Discoloration on SRB Holddown Post M-4

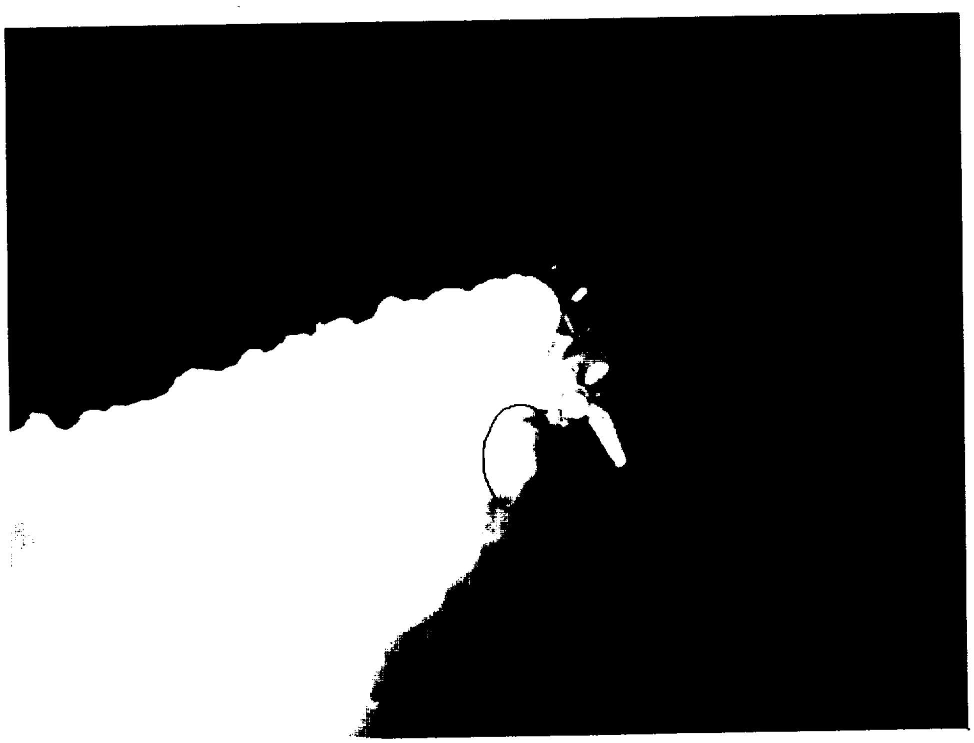
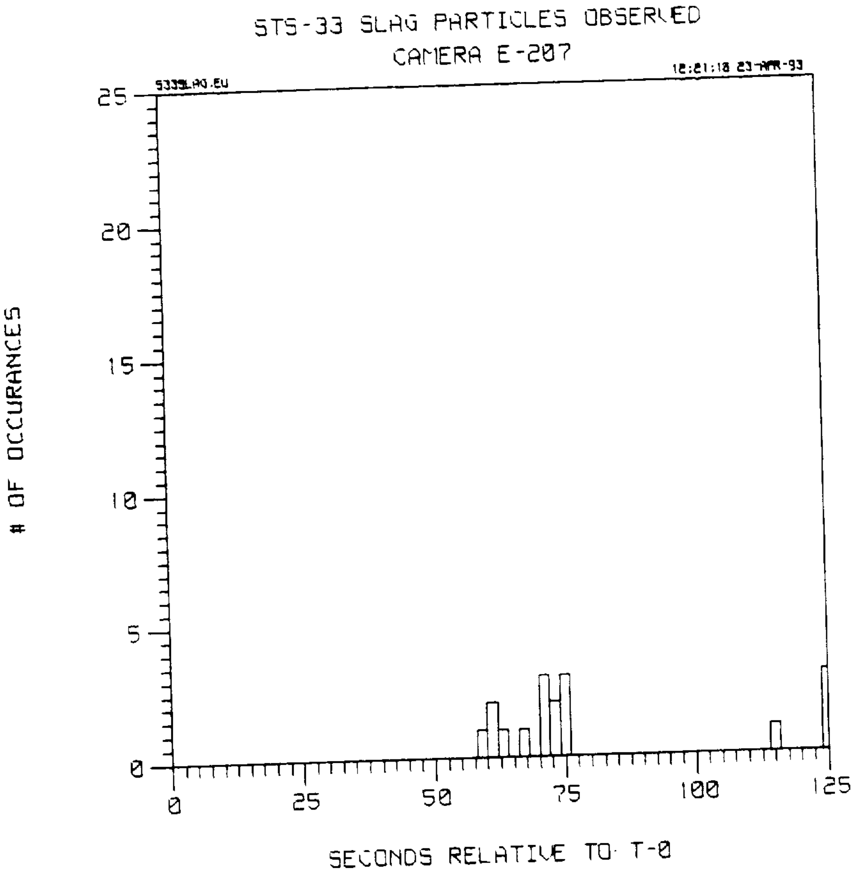
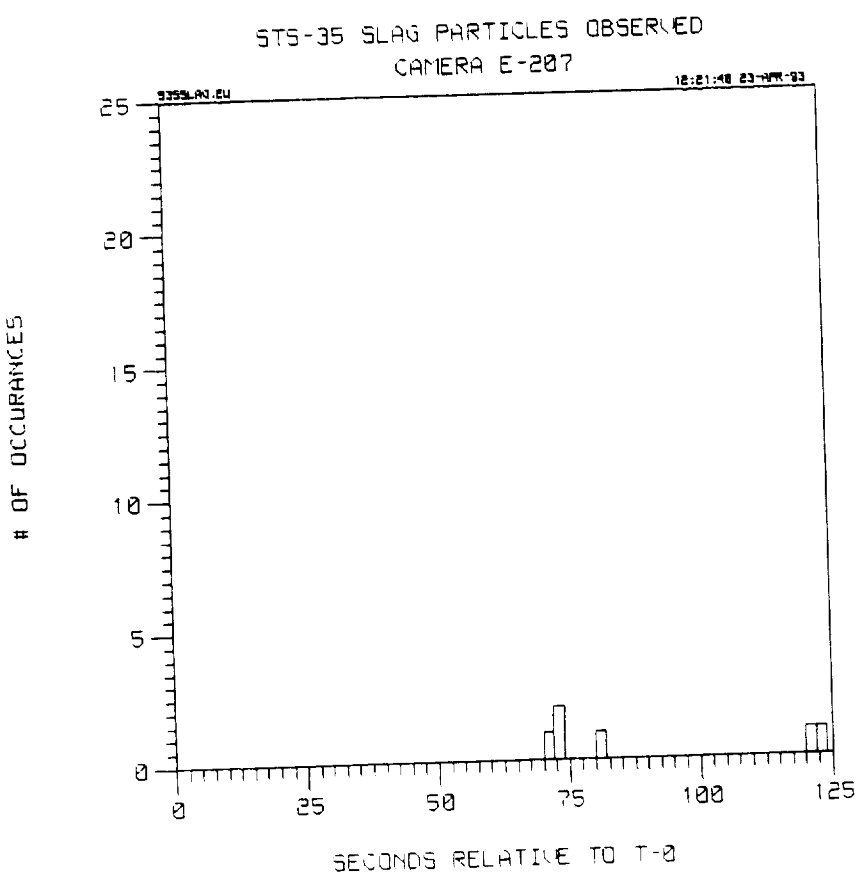


Figure 2 Large Flare in SSME Plume



MSFC ENGINEERING PHOTOGRAPHIC ANALYSIS

Figure 3



Vehicle is obscured by cloud cover for majority of ascent.

MSFC ENGINEERING PHOTOGRAPHIC ANALYSIS

Figure 4

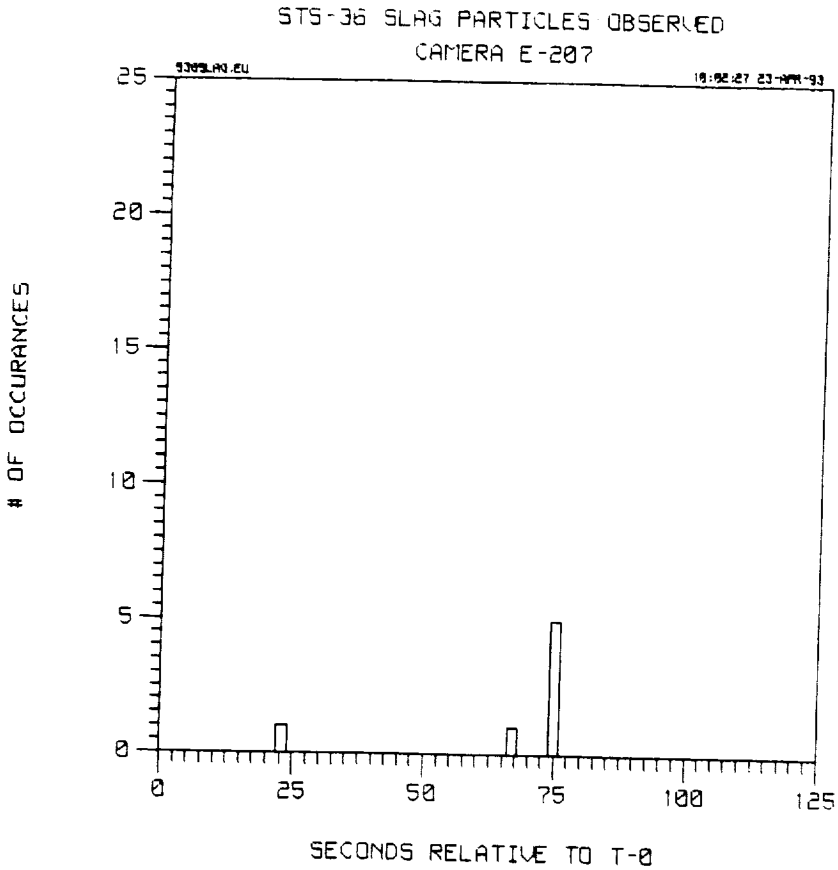


Image quality poor.

Figure 5

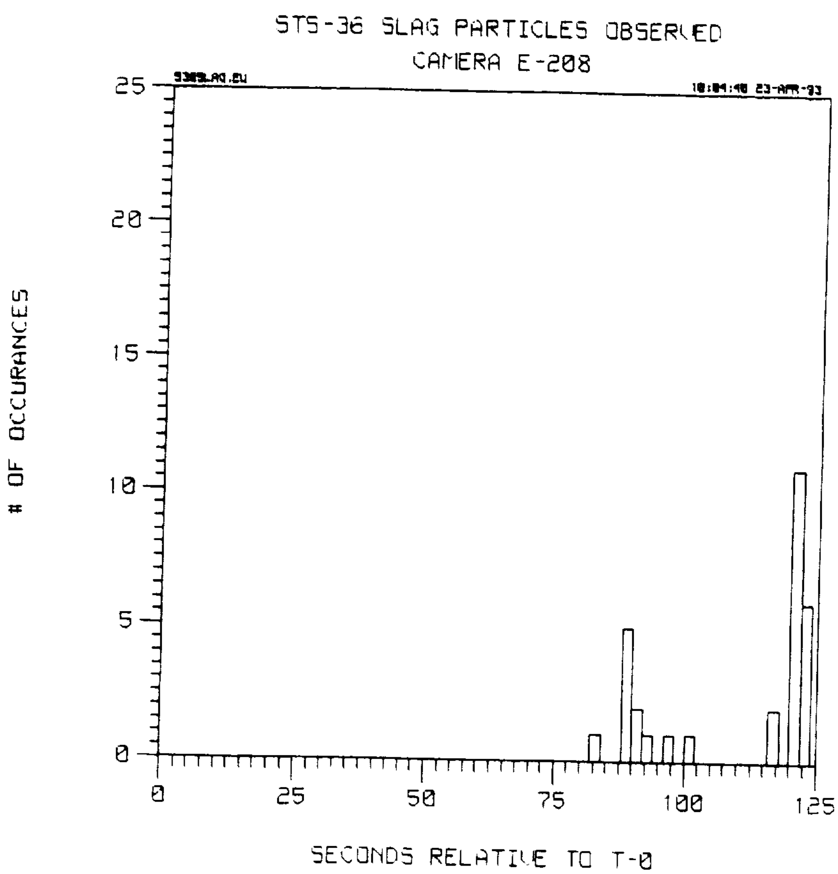
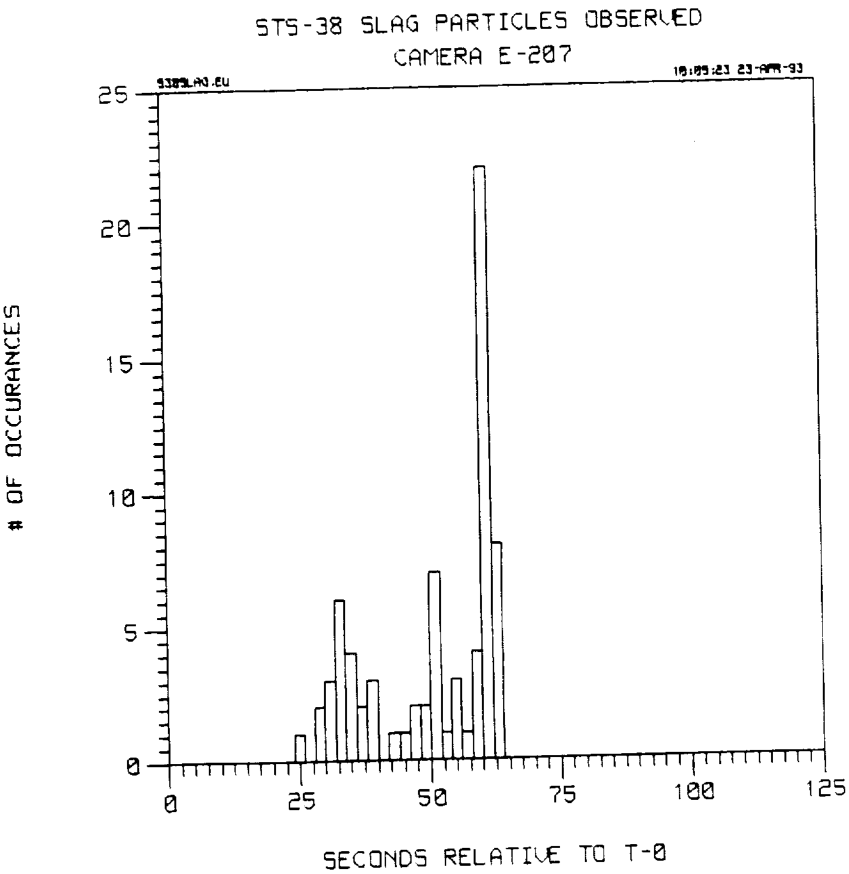


Figure 6



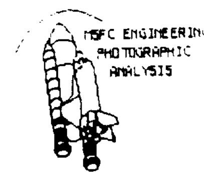
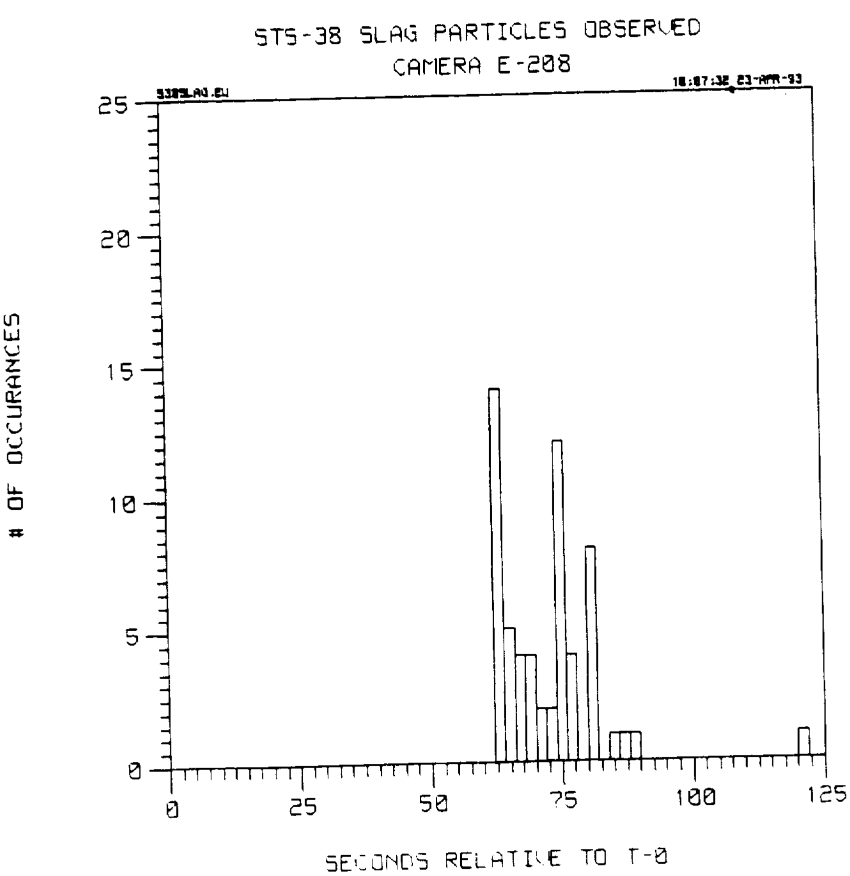


Figure 7



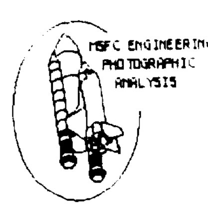
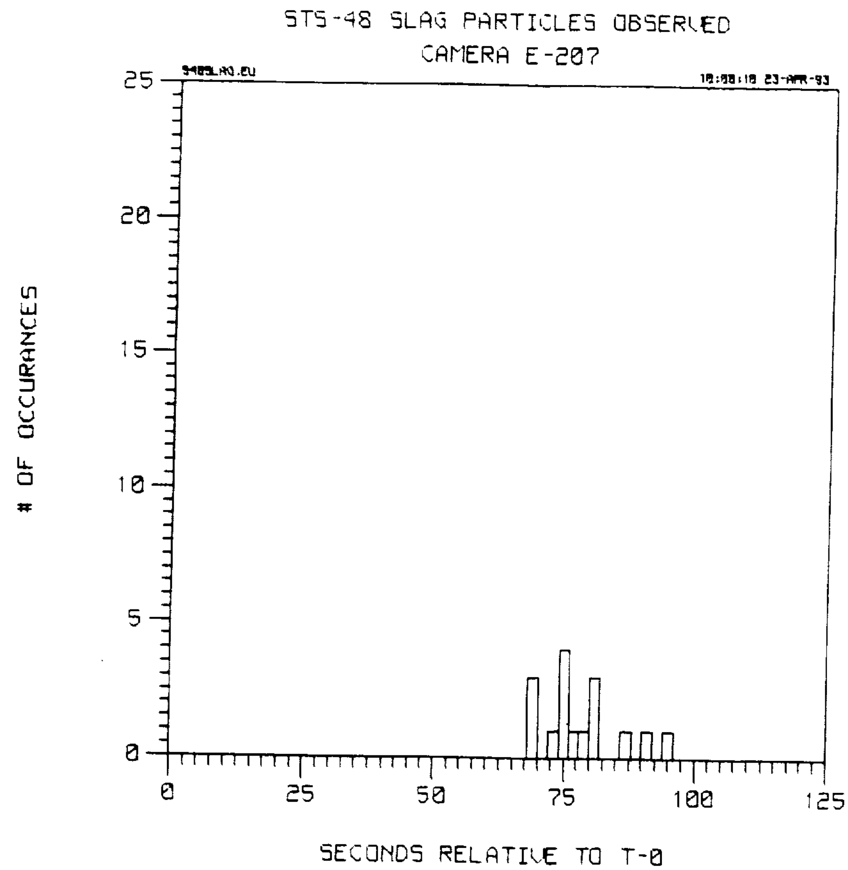


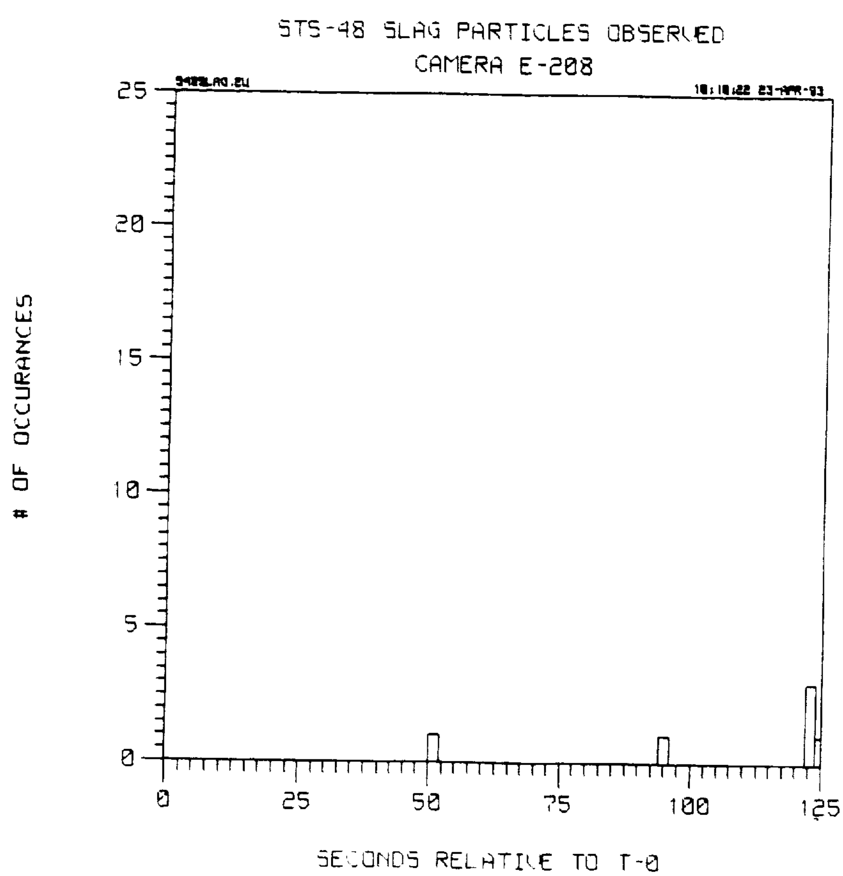
Figure 8



Tight view of vehicle, most of plume is not visible.

MSFC ENGINEERING PHOTOGRAPHIC ANALYSIS

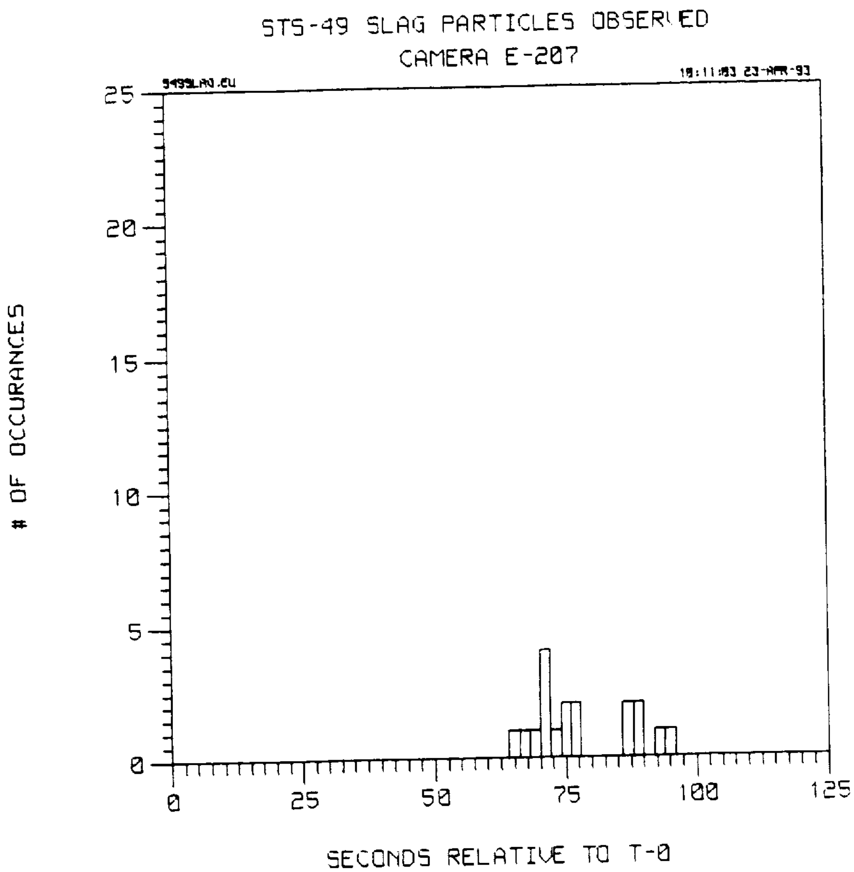
Figure 9



Vehicle mostly obscured by clouds during ascent.

MSFC ENGINEERING PHOTOGRAPHIC ANALYSIS

Figure 10



Vehicle was obscured by clouds after roll maneuver until T+40 seconds.

Figure 11

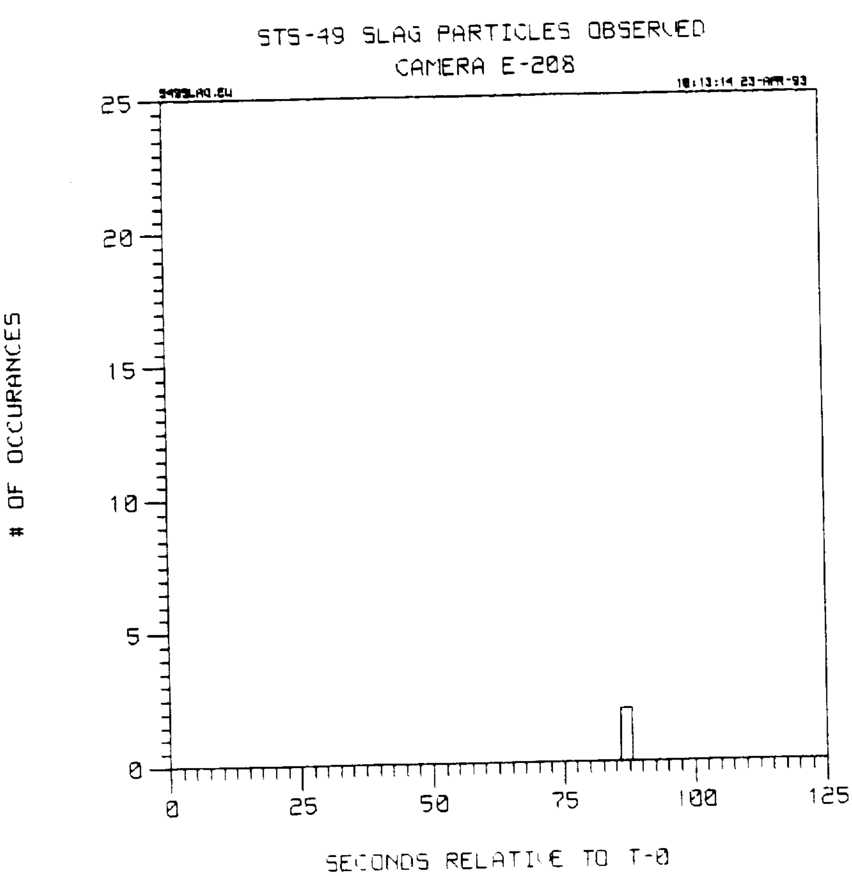


Image size is small and resolution is not good. Tracking is erratic. The vehicle is in the clouds for the majority of ascent prior to SRB separation.

Figure 12

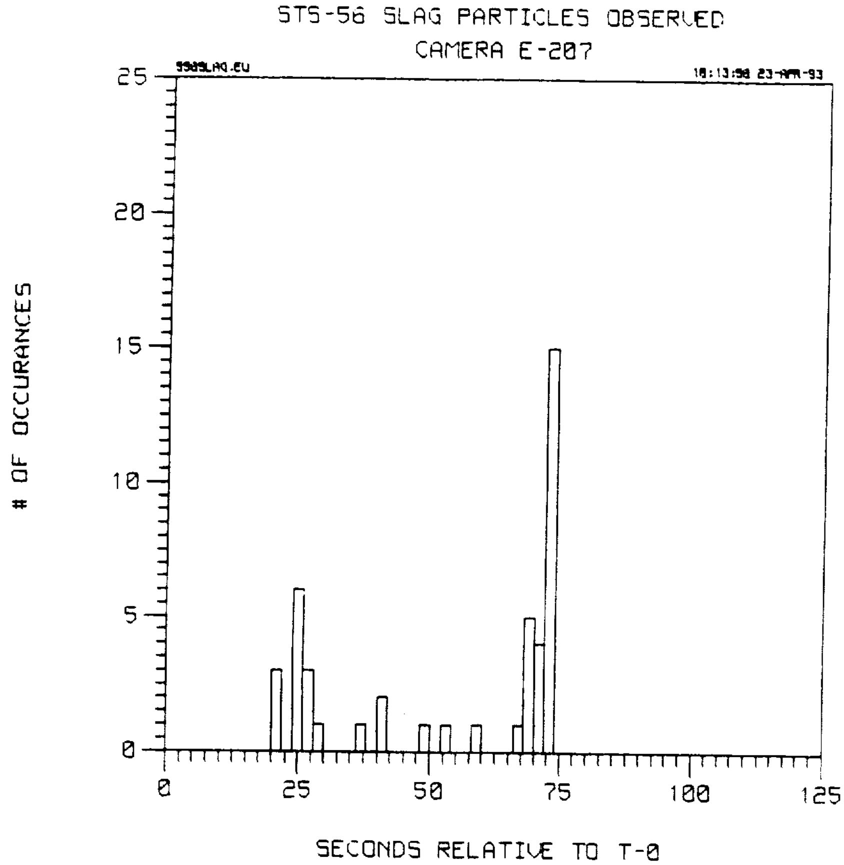


Figure 13

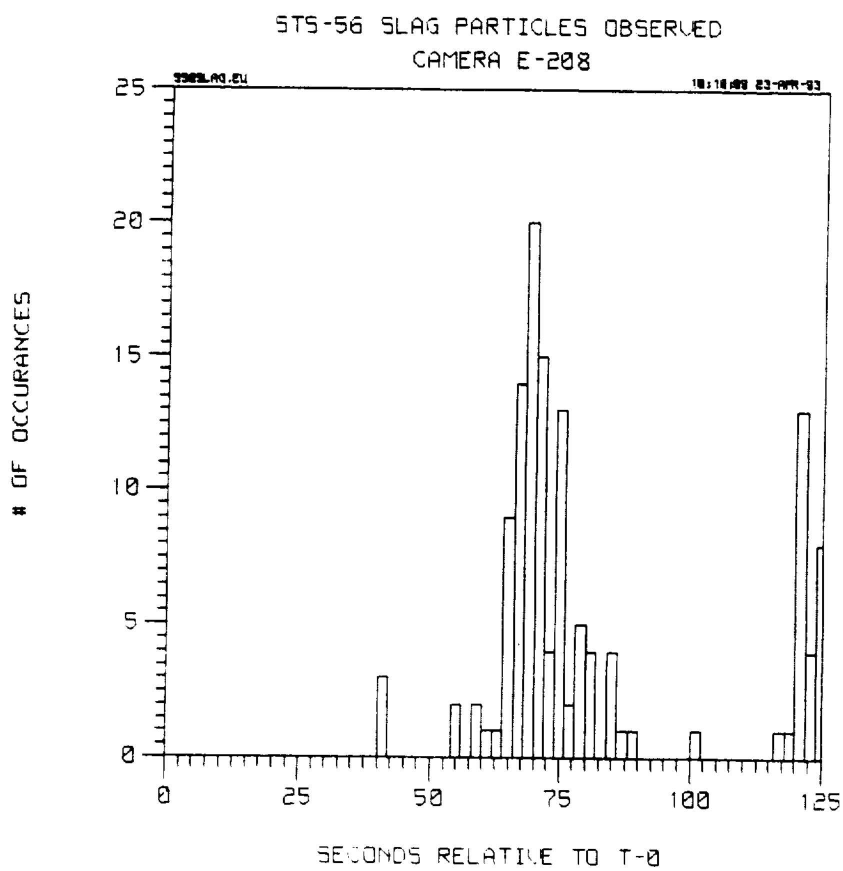


Figure 14

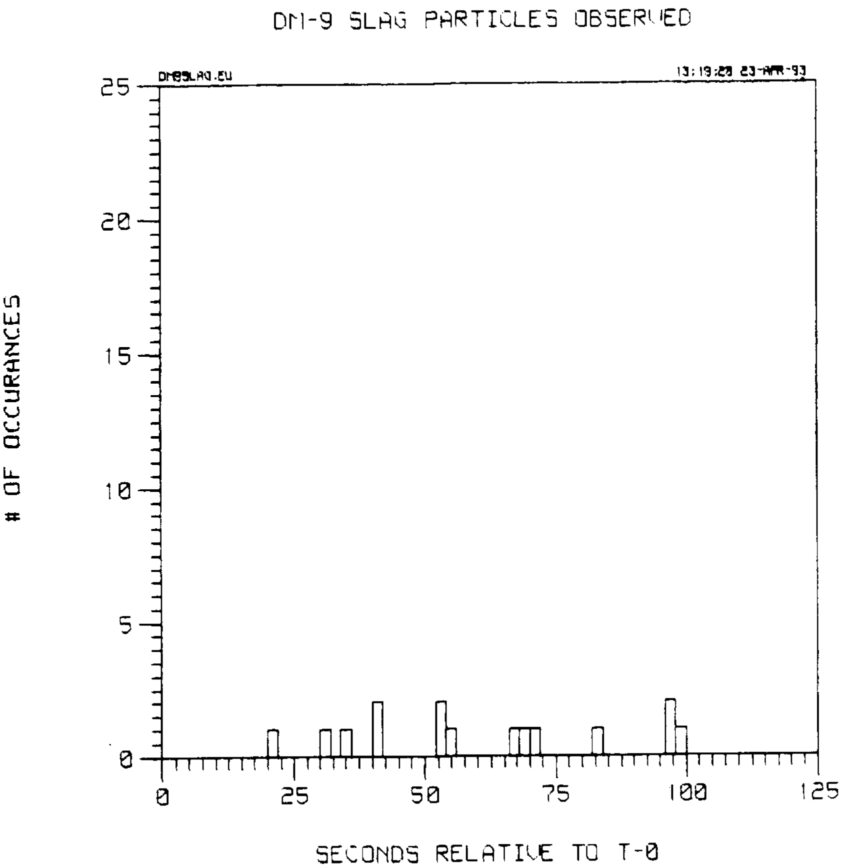


Figure 15

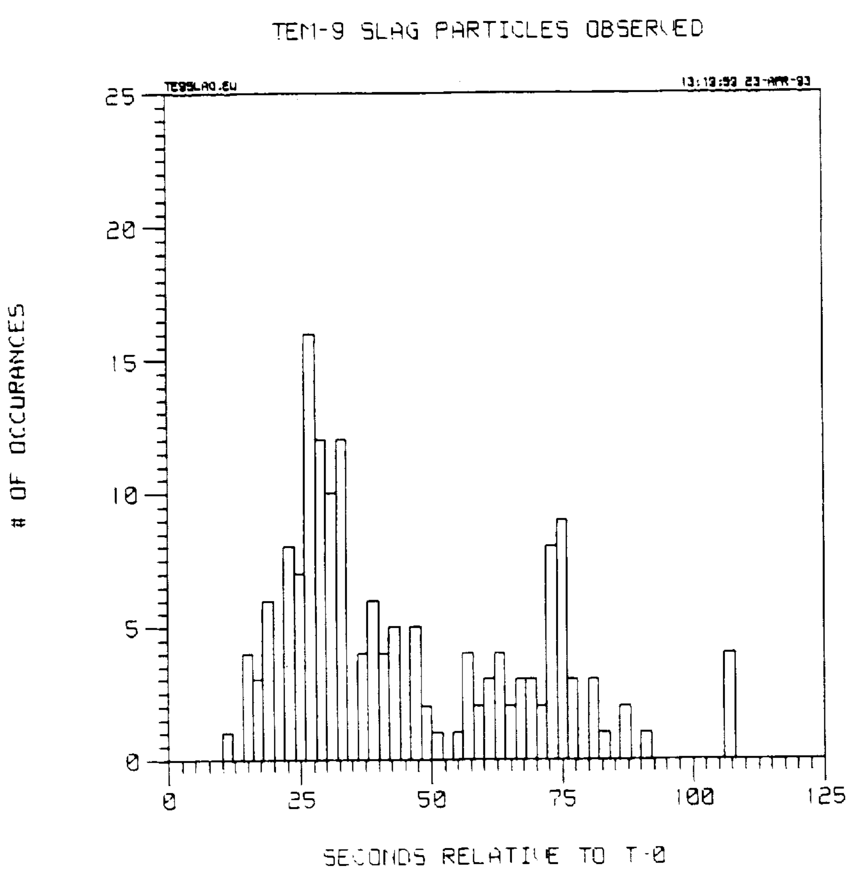


Figure 16

Figure 17 ET TPS Divots

ORIGINAL PAGE
COLOR PHOTOGRAPH

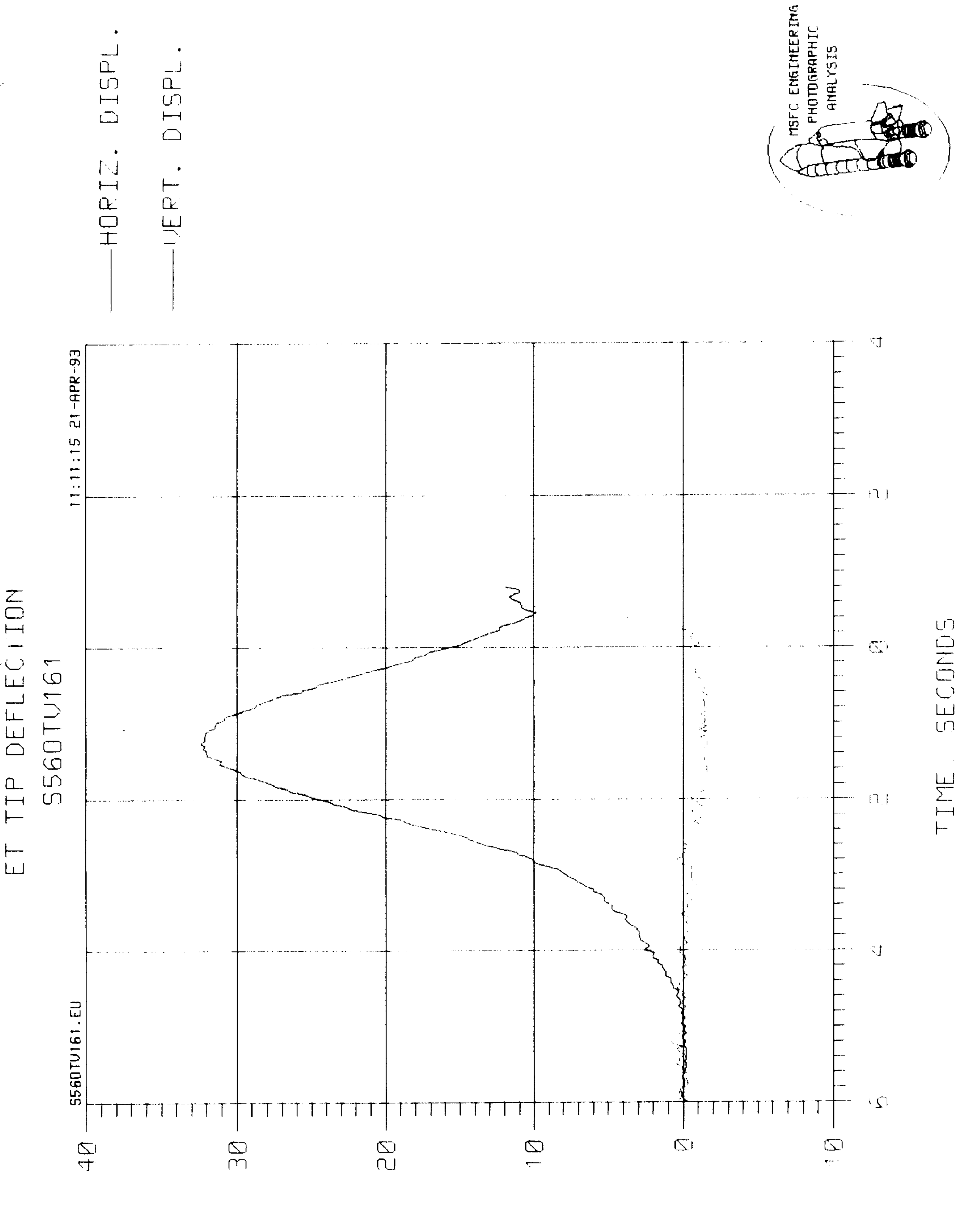

ET TIP DEFLECTION
S560TV161
11:11:15 21-APR-93
S560TV161.EU
HORIZ. DISPL.
VERT. DISPL.
MSFC ENGINEERING
PHOTOGRAPHIC
ANALYSIS
TIME SECONDS
DEFLECTION INCHES
40
30
20
10
0
-10

Figure 18

Appendix C. Rockwell Photographic Analysis Summary

Space Systems Division
Rockwell International Corporation
12214 Lakewood Boulevard
P.O. Box 7009
Downey, California 90241-7009

Rockwell International

May 25, 1993

In Reply Refer to 93MA1787

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77058

Attention: L. G. Williams (WA)

Contract NAS9-18500, System Integration, Transmittal of the Rockwell Engineering Photographic Analysis Report for the STS-56 Mission.

The System Integration Contractor hereby submits the Engineering Photographic Analysis Summary Report in accordance with the Space Shuttle Program Launch and Landing Photographic Engineering Evaluation Document (NSTS 08244).

Extensive photographic and video coverage was provided and has been evaluated to determine ground and flight performance. Cameras (cine and video) providing this coverage are located on the Launch Complex 39B Fixed Service Structure (FSS), Mobile Launch Platform (MLP), various perimeter sites, and uprange and downrange tracking sites for the STS-56 launch conducted on April 8, 1993, at approximately 1:29 AM (EDT) from the Kennedy Space Center (KSC) and for the landing on April 17, 1993 at KSC (7:37 AM EDT).

Rockwell received launch films from 80 cameras (56 cine, 24 video) and landing films from 27 cameras (15 cine, 12 video) to support the STS-56 photographic evaluation effort. Three films, E-12, E-15 and E-26 were not available due to camera malfunction.

All ground camera coverage for this mission including coverage on the MLP, FSS and tracking cameras were good considering that launch was at night. However, due to the poor lighting conditions at night, many of the launch films were hampered in some way. This hindered analysis and possible detection of debris and/or anomalies.

Overall, the films showed STS-56 to be a clean flight. Several pieces of ice from the ET/ORB umbilicals were shaken loose at SSME ignition, but no damage to the Orbiter Thermal Protection System (TPS) was apparent. The usual condensation and water vapors were seen at the ET aft dome and the SRB stiffener rings and dissipated after the completion of the roll maneuver. No vapor was observed in the vicinity of the rudder/speed brake at liftoff. Charring of the ET aft dome, recirculation and brightening of the SRB plumes were visible and normal. Booster Separation Motor (BSM) firing and SRB separation also appeared to be normal.

(Packing Sheet No. DM93-12635)

Nominal performance was seen for the MLP and FSS hardware. FSS deluge water was activated prior to SSME ignition and the MLP rainbirds were activated at approximately 1 second Mission Elapsed Time (MET), as is normal. All blast deflection shields closed prior to direct SRB exhaust plume impingement. Both TSM umbilicals released and retracted as designed. The ET GH2 vent line carrier dropped normally and latched securely with no rebound. No anomalies were identified with the ET/ORB LH2 umbilical hydrogen dispersal system hardware.

STS-56 was the fourteenth flight with the optimized attach link in the SRB holddown support post Debris Containment Systems (DCS's). The link is designed to increase the plunger velocity and seating accuracy, while leaving the holddown bolt ejection velocity unchanged. This prevents frangible nut fragments and/or NSI cartridges from falling from the DCS, while not increasing the probability of a holddown bolt hang-up.

Significant events that were observed were the piece of debris falling aft into the SSME plume causing a bright orange flash and the spring and plunger from the DCS found during the Post Launch MLP debris inspection of holddown post #5. These events and other events noted by the Rockwell film/video users during the review and analysis of the STS-56 photographic items are summarized in the following comments. These events are not considered to be a constraint to next flight.

COMMENTS

1. On camera E-20, (frame 1380) and E223 (frame 4732) a piece of debris was seen falling aft into the SSME plume and caused a bright orange flash aft of the vehicle. This occurred at approximately 45 seconds MET. Follow-on analysis for this event continues at JSC. No further action is planned at RI/Dny.

2. During the post launch MLP debris inspection the plunger and spring from the DCS was found on left SRB holddown post #5 still attached to the stud. This hardware is normally contained in the DCS housing and remains with the SRB aft skirt for flight. Investigation of the anomaly by MSFC/KSC did not disclose any hardware or installation procedure discrepancies.

   A RI-Huntsville study in 1990 concluded that there was a 0.054% (1/1850) possibility that debris from a holddown post of sufficient size could impact flight hardware. This analysis considered all potential debris from holddown posts except the plunger, plunger pieces and spring. The Rockwell assessment of the STS-56 DCS anomaly concluded the additional debris from plunger, plunger pieces and spring fall within the scope of the 1990 analysis and there was no additional debris hazard/risk to STS-56 from the plunger and spring debris. As a result of this assessment, a recommendation was made to launch STS-55 with the current DCS configuration.

No photographic coverage of the left SRB holddown post #5 was obtained due to camera E-12 malfunction (film break at start). No follow-up action is planned.

3. Multiple pieces of white debris (probably ice/frost) were seen falling from the ET/Orbiter umbilicals during SSME ignition on cameras OTV-109, OTV-163, OTV-164, E-6 and E-31. Several pieces appeared to contact the underside of the Orbiter near the umbilical doors. No damage to the vehicle was visible and no follow-up action is planned.

4. Orange vapor (possibly free burning hydrogen) was seen beneath the body flap (cameras OTV-163, E-2, E-30, E-36) and above the rims of SSME #1, SSME #2, and SSME #3 (cameras OTV-170, OTV-171, E-4, E-16) at SSME ignition. This vapor appears to be similar to the vapor noted on previous missions. It is not an issue and no follow-up action is planned.

5. Several orange flashes were noted in the plume of SSME #3 prior to liftoff on cameras OTV-170, E-2, E-3, E-5 and E-19. These flashes are probably debris-induced and have been seen on previous missions. No follow-up action is planned.

6. A thin, rectangular, dark object originated from the left aft Reaction Control System (RCS) stinger area and seen falling aft during SSME ignition on camera E-20. KSC stated this was possibly a tile gap filler or tile shim. No follow-up action is planned.

7. On camera E-19, a light-colored object appeared to originate between the LO2 Tail Service Mast (TSM) carrier plate and the Orbiter and fell aft at liftoff. Also, from camera E-9, a thin rectangular light-colored piece of debris was noted falling through the field of view from left to right in from of the right SRB at liftoff. This two camera views are possibly of the same debris object (piece of duct tape). This debris did not appear to contact the vehicle. No follow-up action is planned.

8. Several bright debris objects (possibly birds) were noted north of the MLP after liftoff at 2.8 seconds MET on cameras KTV-7B, KTV-21B and E-222. The objects did not appear to contact the vehicle. Analysis to determine the position of the debris objects relative to the Orbiter is being performed at JSC. Debris size, velocity, and trajectory will also be determined. No further actions is planned at RI/Dny.

9. A piece of loose thermal curtain tape was observed on the aft skirt of the right SRB during liftoff and prior to the roll maneuver on cameras E-25, E-57, E-220 and E-222. Loose thermal curtain tape has been seen on previous missions and no follow-up action required.

10. Flares and flashes seen in the SSME plume (E-50, E-54, E-207, E-212, E-213, E-218, E-223) during ascent. These observations have been seen in the SSME plumes on previous missions and are understood to be burning of propellant impurities including RCS paper covers. No follow-up action is planned.

11. Large clusters of debris particles were seen falling aft of the Orbiter after completion of the roll maneuver and before SRB separation on cameras E-212, E-220 and E-222. The debris were traced to the forward RCS thrusters and were pieces of the RCS paper covers. No follow-up action is planned.

12. The following events have been reported on previous missions and observed on STS-56. These are not of major concern, but are documented here for information only:
    - Ice debris falling from the ET/Orbiter Umbilical disconnect area.
    - Debris (Insta-foam, water trough) in the holddown post areas and MLP.
    - Charring of the ET aft dome.
    - ET aft dome outgassing after liftoff.
    - Butcher paper falling from the RCS.
    - Recirculation or expansion of burning gases at the aft end of the SLV prior to SRB separation.
    - Slight TPS erosion on the base heat shield during SSME start-up.
    - Twang motion.
    - Body flap motion during the maximum dynamic pressure (MAX-Q) region which appeared to have an amplitude and frequency similar to those of previous missions.
    - Linear optical distortion, possibly caused by shock waves or ambient meteorological conditions near the vehicle, during ascent.
    - Slag in SRB plume after separation.
    - Condensation around the SLV during ascent.
    - Vapor from the SRB stiffener rings after liftoff.
    - Fore-and aft movement of the Orbiter base heat shield in the centerline area between the SSME cluster at engine start-up.

13. Cameras E33 and E41 - OMRSD File IX Vol. 5, Requirement No. DV08P.010 requires an analysis of launch pad film data to verify that the initial ascent clearance separation between the left SRB outer mold line and the falling ET vent umbilical structure does not violate the acceptable margin of safety.

    A qualitative assessment has been conducted and positive clearances between the left SRB and the ET vent umbilical have been verified. The films showed nominal launch pad hardware performance, and no anomalies were observed for the SRB body trajectory.

14. Cameras E7-16 and E27-E28 - OMRSD File IX Vol. 5, Requirement No. DV08P.020 requires an analysis of film data of SRM nozzle during liftoff to verify nozzle to holddown post drift clearance.

    A qualitative assessment of the launch films has been completed. No anomalies were observed for the SRM nozzle trajectory and positive clearances between the SRB nozzles and the holddown posts were verified.

15. The landing of STS-56 occurred on runway 33 at the KSC Shuttle landing facility. Good video and film coverage were obtained and no anomalous events were observed. This flight marked the seventh use of the Orbiter drag

chute. The drag parachute system performed as expected. All sequenced events occurred as expected and no hardware anomalies were observed.

During the post-landing inspection several tiles were damaged on the right aft edge of the vertical stabilizer stinger. This area has sustained damage on previous uses of the drag chute by contact with the parachute riser lines. No follow-up action has been requested.

This letter is of particular interest to Messers W. J. Gaylor (VF2) and C. F. Martin (MK-SIO-2) at NASA/JSC and NASA/KSC respectively. The Integration Contractor contact is R. Ramon at (310) 922-3679.

ROCKWELL INTERNATIONAL
Space Systems Division

J. A. Wolfelt
Chief Engineer
System Integration

RR/ly

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13. ABSTRACT (*Maximum 200 words*)

A Debris/Ice/TPS assessment and integrated photographic analysis was conducted for Shuttle mission STS-56. Debris inspections of the flight elements and launch pad were performed before and after launch. Ice/Frost conditions on the External Tank were assessed by the use of computer programs, nomographs, and infrared scanner data during cryogenic loading of the vehicle followed by on-pad visual inspection. High speed photography was analyzed after launch to identify ice/debris sources and evaluate potential vehicle damage and/or in-flight anomalies. This report documents the debris/ice/TPS conditions and integrated photographic analysis of Shuttle mission STS-56, and the resulting effect on the Space Shuttle Program.

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